ACTA AGRONOMICA
ACADEMIAE SCIENTIARUM HUNGARICAE

TOMUS XXIX FASCICULI 1–2

AKADÉMIAI KIADÓ, BUDAPEST
1980

ACTA AGRON. HUNG.

ACTA AGRONOMICA

A MAGYAR TUDOMÁNYOS AKADÉMIA
AGRÁRTUDOMÁNYI KÖZLEMÉNYEI

SZERKESZTŐSÉG ÉS KIADÓHIVATAL: 1054 BUDAPEST, ALKOTMÁNY UTCA 21.

Az Acta Agronomica angol nyelven közöl értekezéseket az agrártudomány tárgyköréből, főképpen a mezőgazdasági alapkutatások területéről.

Az Acta Agronomica változó terjedelmű füzetekben jelenik meg, több füzet alkot egy kötetet.

A közlésre szánt kéziratok a következő címre küldendők:

Acta Agronomica
2462 Martonvásár, Postafiók 19.

Ugyanerre a címre küldendő minden szerkesztőségi és kiadóhivatali levelezés.

Megrendelhető a belföld számára az Akadémiai Kiadónál (1363 Budapest, Pf. 24. Bankszámla 215-11488), a külföld számára pedig a „Kultúra" Külkereskedelmi Vállalatnál (1389 Budapest 62, P. O. B. 149. Bankszámla: 218-10-990) vagy annak külföldi képviseleteinél.

The Acta Agronomica publishes papers in English on agronomical subjects, mostly on basic research.

The Acta Agronomica appears in one volume (four issues) a year.

Manuscripts should be addressed to:

Acta Agronomica
H-2462 Martonvásár, Postafiók 19.

Subscription: $ 36.00 a volume.

Orders may be placed with "Kultúra" Foreign Trading Company (H-1389 Budapest 62, P. O. B. 149, Bank Account No. 218-10-990) or its representatives abroad.

Acta Agronomica Academiae Scientiarum Hungaricae, Tomus 29 (1—2), pp. 1—11 (1980)

DORMANCY IN FRUITS OF TILIA PLATYPHYLLOS SCOP

IV. CHANGES IN THE ENDOGENOUS GIBBERELLIN CONTENT DURING STRATIFICATION

By

M. NAGY

JÓZSEF ATTILA UNIVERSITY, DEPARTMENT OF PLANT PHYSIOLOGY, SZEGED

Quantitative changes in various forms of gibberellin occurring in *Tilia platyphyllos* seeds during stratification were studied using the lettuce hypocotyl and barley endosperm tests. From dormant, non-stratified seeds various forms of gibberellin, including free gibberellin-like substances, were detected, which suggests that it is the right level, rather than the presence, of free gibberellins that is required to break dormancy and start germination. A sudden increase in the quantity of ethyl-acetate soluble free gibberellin-like substances is observed from the sixth week of stratification. During stratification considerable biological activity takes place in the butanol soluble fraction containing gibberellin conjugates, probably as a result of non-specific glucosidase activity. The identical Rf-values found for the gibberellin-like substances obtained after the hydrolysis of the butanol soluble fraction, and for those of the ethyl acetate fraction indicate a genetic relationship between the gibberellin conjugates and the free gibberellins. In the TCA-insoluble fraction, which contains gibberellins bound to macromolecules, a low degree of biological activity was found, but only one of the active spots showed a quantitative change. CCC treatment during stratification does not inhibit germination in seeds, which points to the fact that the quantitative increase in free gibberellin-like substances is mostly due to a release from the bound forms rather than to *de novo* synthesis.

Introduction

Of all the physiological effects of gibberellin its ability to break dormancy and stimulate germination is the best known.

In many species the stratification requirement can be successfully replaced by exogenous GA_3 treatment (AMEN 1968, JUNTTILA 1970, ROSS—BRADBEER 1971, KOPCEWICZ—PORAZINSKI 1973, BASKIN—BASKIN 1970, 1974). These findings justified the examination of changes in the endogenous gibberellin level during stratification, in the course of which some authors (FRANKLAND—WAREING 1962, 1966, ROSS—BRADBEER 1968, KENTZER 1966) pointed out that the endogenous gibberellin content of the seeds increased during the stratification, suggesting a relationship between the increase in gibberellin content and the termination of dormancy.

In earlier investigations with *Tilia platyphyllos* seeds we too found the endogenous free gibberellins to increase during stratification, but we did not succeed in replacing the stratification by exogenous GA_3 (NAGY—SZALAI 1973, SZALAI—NAGY 1974). Naturally this does not mean that the gibberellins are of no importance in breaking the dormancy of *Tilia* seeds, since there are great differences between the gibberellins in their effect on germination (IKUMA—THIMANN 1963). In order to get a better knowledge of the role of endogenous gibberellins in developing the promotor level the forms of gibberellin occurring in the dormant seed and their changes during stratification were examined.

Material and Method

Material of examination. A population stock obtained from the Forestry of County Csongrád was used in the examinations.

Stratification. After the pericarp had been removed the seeds were scarified with sulphuric acid, then stratified in culture pots containing washed sand wetted to 80% of the full water capacity. Stratification was carried out in a refrigerator at 4—5°C.

Treatment of seeds with CCC and ABA solutions. After scarification the seeds were kept in Petri-dishes between filter paper discs wetted with 500 ppm ABA solution or 1000 ppm CCC solution in a refrigerator (at 5°C) for 3 months, then placed at room temperature.

Extraction and chromatographic separation of gibberellins. At the beginning of stratification, then after 3, 6, 9 and 12 weeks of stratification 2000 seeds were removed from the culture pots on each occasion. The sand was washed off the seeds, then the seeds were homogenized in a cooled homogenizator and extracted with 80% methanol in a refrigerator for 2×24 hours. The combined methanol extract was separated into ethyl acetate soluble and butanol soluble acidic fractions by the method of HARADA—YOKOTA (1970). The ethyl acetate soluble acidic fraction which contained the free gibberellins was evaporated under reduced pressure and chromatographed on a silica gel G layer. The solvent was diisopropyl-ether : acetic acid (95 : 5) (REINHARD *et al.* 1964). The butanol soluble acidic fraction which contained the gibberellin conjugates was divided in two parts. One of them was first evaporated under reduced pressure and then chromatographed with chloroform : methanol : acetic acid : water (40 : 15 : 3 : 2) as solvent (HARADA—YOKOTA 1970), while the other part was hydrolysed with N H_2SO_4 or β-glucosidase at 60°C for 2 hours (YOKOTA *et al.* 1969). The gibberellins released during the hydrolysis were extracted with ethyl acetate, then the ethyl acetate extract was evaporated under reduced pressure and subjected to thin layer chromatography.

The tissue homogenizate left behind after the methanol extraction, which contained the gibberellins bound to macromolecules, was suspended in phosphate buffer (pH 8.0) after the solvent residues had been evaporated. After centrifuging, the supernatant was treated with 10% TCA. After repeated centrifuging the precipitate was hydrolysed with 2 N NaOH at 40°C for 4 hours. After acidification with hydrochloric acid (pH 3.0) the gibberellins released were extracted with ethyl acetate, then evaporated and subjected to thin layer chromatography.

Determination of biological activity

Lettuce hypocotyl test. The chromatogram was divided into ten equal parts, and the silica gel was scraped into Petri dishes 7 cm in diameter. The powder was covered with a filter paper disc and wetted with distilled water. The biological activity was measured using the lettuce (variety: "Aranysárga kőfej") hypocotyl test, according to the FRANKLAND—WAREING (1960) method. As a control a developed and tested silica gel layer without plant extract was used.

Barley endosperm test. The powder scraped off the layer was eluated with ethyl acetate or n-butanol. The eluate was evaporated to dryness under reduced pressure, the residue was taken up in 2 ml acetate buffer containing 20 μM $CaCl_2$ (pH 4.8) and tested with barley endosperm by the method of JONES—WARNER (1967) under sterile conditions. After 24 hours of incubation 1% starch, prepared with 1 ml acetate buffer containing 20 μM $CaCl_2$ (pH 4.8), was added to 1 ml of the incubation solution. It was incubated at 40°C for 10 minutes, then 1 ml was removed and a 0.0003 N KI-I_2 solution, prepared with 10 ml 0.03 N hydrochloric acid, was added to it. The optical density of the mixture was measured at 580 nm. The amount of α-amylase was calculated with the formula given by JONES—WARNER (1967). As a control, a developed and tested silica gel layer containing no plant extracts was used.

Results

1. Quantitative changes in the endogenous free gibberellin-like substances during stratification

In the course of seed maturation a transformation of free gibberellins into inactive, bound forms can be observed. According to SEMBDNER *et al.* (1968), in the mature seeds of *Phaseolus coccineus* only bound gibberellins can be found. Attempts to detect gibberellin activity in dormant seeds of *Fraxinus excelsior* (KENTZER 1966, SZALAI—NAGY 1968) and *Corylus avellana* (FRANKLAND—WAREING 1966) also failed.

On the other hand, gibberellin activity could be detected in dormant seeds of *Fagus sylvatica* (FRANKLAND—WAREING 1966), *Acer platanoides* (TOMASEWSKA 1976) and apple (SINSKA—LEWAK 1970). On the basis of these contradictory data it is difficult to decide whether the appearance of the free gibberellins is the decisive momentum in the termination of dormancy.

Quantitative changes in the endogenous free gibberellin-like substances of *T. platyphyllos* seeds during stratification are shown in Fig. 1 (A and B).

Since the gibberellins show different biological activities in the different tests (REEVE 1974) two kinds of biological tests were used to study the change in the endogenous gibberellin content (lettuce hypocotyl and barley endosperm). The barley endosperm is responsive to lower gibberellin concentrations than the lettuce hypocotyl, and is not inhibited by solvent residues which might be contained in the extract; the lettuce hypocotyl test, on the other hand, reacts to a wider range of gibberellins (JONES—WARNER 1967).

As shown by the figures, in the dormant, non-stratified *T. platyphyllos* seeds free gibberellin-like substances occur in demonstrable quantities. The lettuce hypocotyl test (A) displayed the presence of six kinds of free gibberellin-like substances; four of them showed significant quantitative changes during the stratification. A sudden quantitative increase can be observed from the sixth week of stratification.

Similar results were arrived at with examinations made with the barley endosperm test (B), except that in this case the presence of a gibberellin-like substance in the Rf 0.5—0.6 position could not be detected.

2. Quantitative changes in gibberellin conjugates in the butanol soluble fraction during stratification

According to the literary data the gibberellin conjugates (gibberellins bound to smaller molecules) show no biological activity in dwarf plant tests (KATSUMI 1971, 1973). However, in the biological tests used in the present work the butanol soluble fraction displayed considerable biological activity.

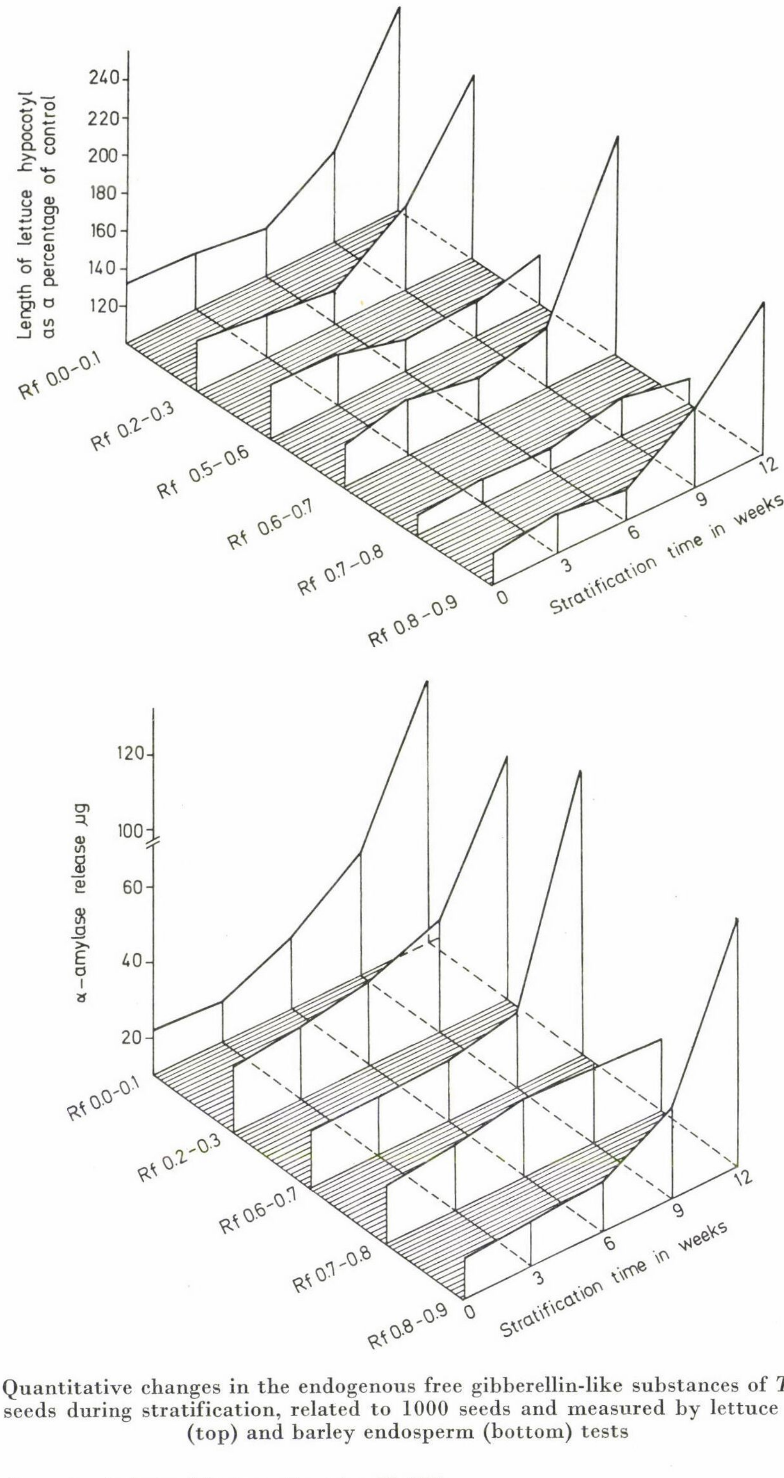


Fig. 1. Quantitative changes in the endogenous free gibberellin-like substances of *Tilia platyphyllos* seeds during stratification, related to 1000 seeds and measured by lettuce hypocotyl (top) and barley endosperm (bottom) tests

The observed biological activity may be due to gibberellins released by non-specific glucosidases which do not normally establish contact with the endogenous gibberellin conjugates (REEVE 1974, SEMBDNER *et al.* 1976).

Quantitative changes in the gibberellin-like substances contained in the butanol soluble fraction are shown in Fig. 2 (A and B). According to the results of both tests, up to the 9th week of stratification a reduction in the quantity of gibberellin conjugates can be observed. The most important change usually occurs between the 6th and 9th weeks. After the 9th week the quantity of gibberellin-like substances shows a slight increase.

The free gibberellin-like substances were released from the conjugates contained in the butanol soluble fraction by hydrolysis; no difference was found, however, between the results obtained with the two types of hydrolysis. The results of biological testing after the acid hydrolysis are represented in Fig. 3 (A and B). As seen from the figure, the quantitative changes in both tests were similar in tendency to the results of testing before hydrolysis, but the biological activity was lower in each case. On comparing the gibberellin glucosyl esters and the free acids for biological activity, HIRAGA *et al.* (1974) also found the activity of the conjugates to be higher than that of the free acids.

The fact that the gibberellin-like substances obtained after the hydrolysis of the butanol soluble fraction and the gibberellin-like substances of the ethyl acetate fraction have the same Rf-values indicates a genetic relation between the gibberellin conjugates and the free gibberellins.

3. Quantitative changes in the macromolecule-bound gibberellins contained in the TCA-insoluble fraction during stratification

The existence of protein-bound gibberellins is supposed by a number of authors (MCCOMB 1961, HAYASHI—RAPPAPORT 1962, REINHARD—SACHER 1967, JONES 1964, 1968, GINSBURG—KENDE 1968); nevertheless, their occurrence is still debated. According to LANG (1970) the assumption of gibberellins bound to proteins is not properly grounded as yet. ASAKAWA *et al.* (1974) have also arrived at the conclusion that *in vivo* the gibberellin does not become bound to protein fractions. STODDART *et al.* (1974), on the other hand, detected the presence of GA_1-protein complexes in dwarf pea homogenizates, while KNÖFEL *et al.* (1975) and KONJEVIČ *et al.* (1976) found gibberellins to be bound to proteins *in vitro*.

The nature of gibberellin-protein complexes is not known. According to JONES (1968) under the influence of the organic solvents used in the process of extraction these complexes precipitate, therefore the amount of gibberellin bound to macromolecules can be determined by the aid of the tissues remaining after the solvent residues have been evaporated.

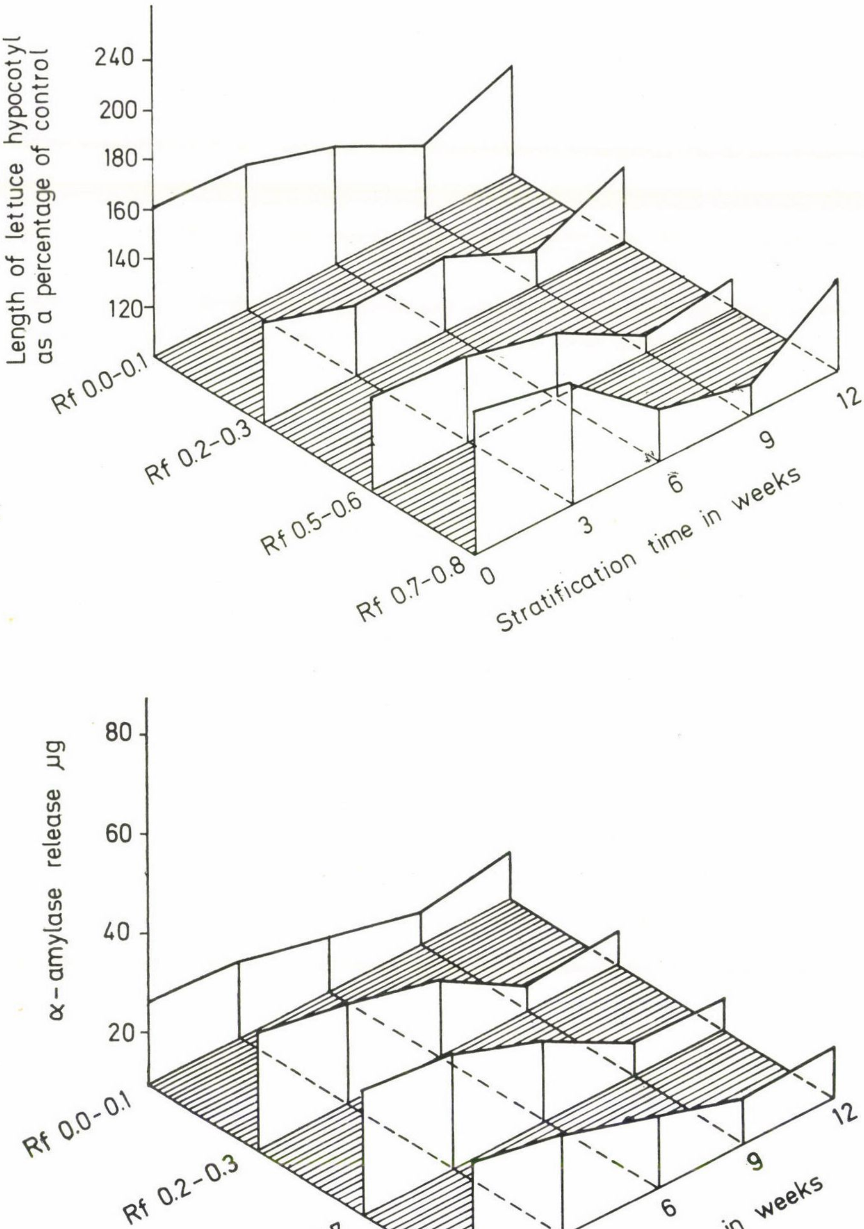


Fig. 2. Quantitative changes in the gibberellin conjugates contained in the butanol soluble fraction during the stratification of *Tilia platyphyllos* seeds, related to 1000 seeds and measured by lettuce hypocotyl (top) and barley endosperm (bottom) tests

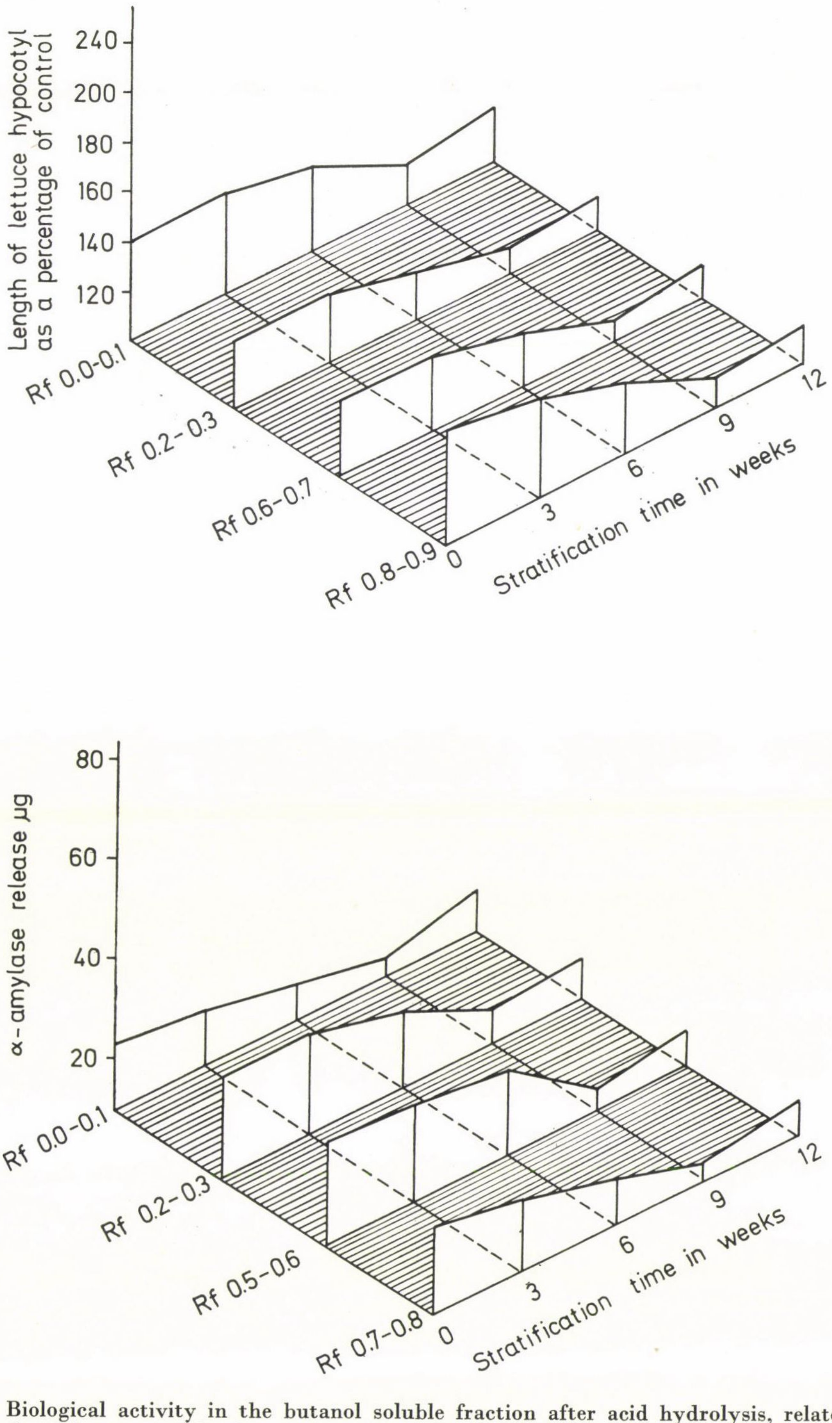
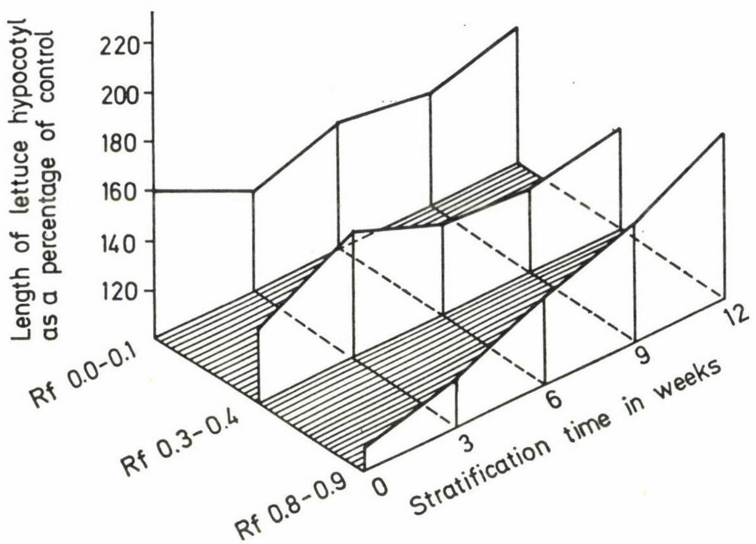


Fig. 3. Biological activity in the butanol soluble fraction after acid hydrolysis, related to 1000 seeds and measured by lettuce hypocotyl (top) and barley endosperm (bottom) tests



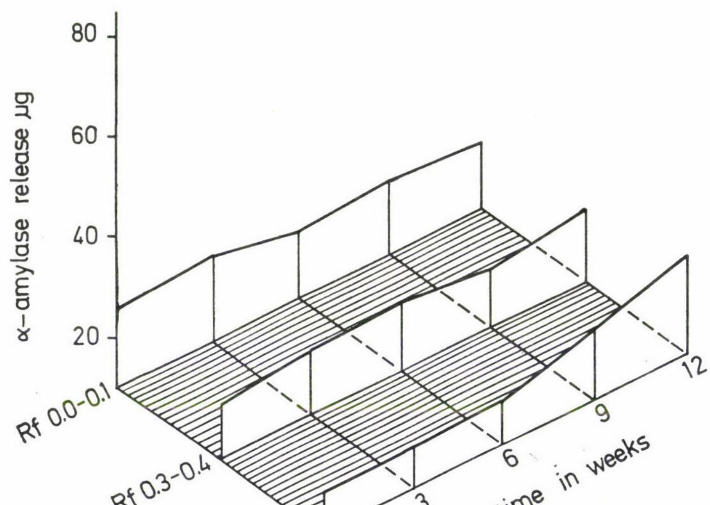


Fig. 4. Quantitative changes in the macromolecule-bound gibberellins found in the TCA-insoluble fraction during the stratification of *Tilia platyphyllos* seeds, related to 1000 seeds and measured by lettuce hypocotyl (top) and barley endosperm (bottom) tests

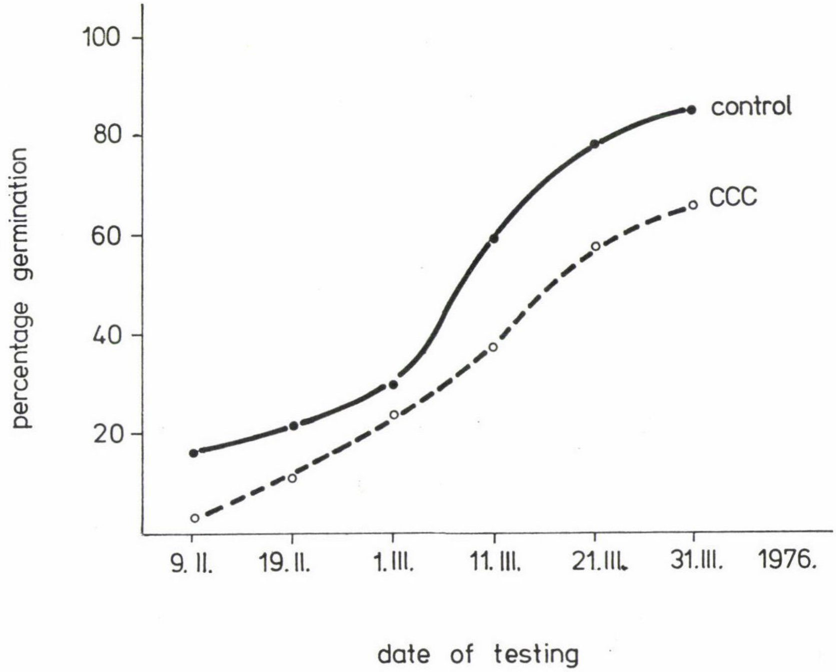


Fig. 5. Effect of CCC treatment on the germination of *Tilia platyphyllos* seeds. The seeds were stratified for 3 months, then kept at room temperature

The biological activity observed after the alkaline hydrolysis of the TCA-insoluble fraction, followed, in the case of acidic pH, by extraction with ethyl acetate, is seen in Fig. 4 (A and B). In the TCA-insoluble fraction both tests revealed three low activity gibberellin-like substances of which only that at Rf 0.9—0.9 showed any considerable quantitative change during stratification.

4. *Effect of CCC and ABA treatments on seed germination*

In order to decide whether the increase in the endogenous free gibberellin content observed during the stratification of *Tilia platyphyllos* seeds was a *de novo* synthesis or the result of release from the bound forms the seeds were kept after scarification in Petri dishes between filter papers wetted with 1000 ppm CCC or 500 ppm ABA solution, in a refrigerator for 3 months, then at room temperature to induce germination.

CCC, which is often used to inhibit gibberellin biosynthesis in both lower and higher plants (Harada—Lang 1965, Jones—Phillips 1966), blocks the cyclization process of the geranyl-geranyl pyrophosphate.

ABA, on the other hand, has been shown (Nadeau *et al.* 1972, Musgrave *et al.* 1972) to promote the transformation of free gibberellins into gibberellin conjugates and thereby to promote the onset of dormancy. Presumably it hinders the opposite process — the release from bound gibberellins — which is also connected with its role in maintaining the state of dormancy.

Our results are shown in Fig. 5. According to our investigation the CCC treatment does not inhibit germination, which means that the increase in the endogenous free gibberellin content during stratification is probably due to a release from the bound forms. However, since the CCC treatment delays germination compared to the control, it is possible that a small extent of *de novo* synthesis is also present, on which the rapidity of germination depends.

When the seeds were treated with ABA no germination was observed.

References

AMEN, R. D. (1968): A model of seed dormancy. Bot. Rev., **34,** 1—31.

ASAKAWA, Y.—TAMARI, K.—INOUE, K.—KOJI, I. (1974): Translocation and intercellular distribution of tritiated gibberellin A_3. Agr. Biol. Chem., **38,** 713—771.

BASKIN, J. M.—BASKIN, C. C. (1970): Replacement of chilling requirements in seeds of *Ruellia humilis* by gibberellic acid. Planta, **94,** 250—252.

BASKIN, J. M.—BASKIN, C. C. (1974): Breaking dormancy in seeds of *Isanthus brachiatus (Labiatae)* with gibberellic acid. Fiton, **32,** 159—165.

FRANKLAND, B.—WAREING, P. F. (1960): Effect of gibberellic acid on hypocotyl growth of lettuce seedlings. Nature, **185,** 255—256.

FRANKLAND, B.—WAREING, P. F. (1962): Changes in endogenous gibberellins in relation to chilling of dormant seeds. Nature, **194,** 313—314.

FRANKLAND, B.—WAREING, P. F. (1966): Hormonal regulation of seed dormancy in hazel (*Corylus avellana* L.) and beech (*Fagus sylvatica* L.). J. Exp. Bot., **17,** 596—611.

GINSBURG, C.—KENDE, H. (1968): Studies on the intercellular localization of radioactive gibberellin. In: Biochemistry and physiology of plant growth substances. Eds.: Wightman, F., Setterfield, G. Ottawa, The Runge Press, 333—341.

HARADA, H.—LANG, A. (1965): Effect of some (2-chloroethyl)-trimethyl-ammonium chloride analogues and other growth retardants on gibberellin biosynthesis in *Fusarium moniliforme*. Plant Physiol., **40,** 176—183.

HARADA, H.—YOKOTA, P. (1970): Isolation of gibberellin A_3-glucoside from shoot apices of *Althea rosea*. Planta, **92,** 100—104.

HAYASHI, T.—RAPPAPORT, L. (1962): Gibberellin activity of neutral and acidic substances in the potato tuber. Nature, **195,** 617—618.

HIRAGA, K.—YAMANE, H.—TAKAHASHI, N. (1974): Biological activity of some synthetic gibberellin glucosyl esters. Phytochem., **19,** 2371—2376.

IKUMA, H.—THIMANN, K. V. (1963): Activity of gibberellin "D" on the germination of photosensitive lettuce seeds. Nature, **197,** 1313—1314.

JONES, R. L. (1964): Examination of the gibberellins of *Zea mays* and *Phaseolus multiflorus* using thin layer chromatography. Nature, **202,** 1303—1310.

JONES, R. L. (1968): Aqueous extraction of gibberellins from pea. Planta, **81,** 97—105.

JONES, R. L.—PHILLIPS, I. D. J. (1966): Effect of CCC on the gibberellin content of excised sunflower organs. Planta, **72,** 53—59.

JONES, R. L.—WARNER, J. H. (1967): The bioassay of gibberellins. Planta, **72,** 155—161.

JUNTILLA, O. (1970): Effects of stratification, gibberellic acid and germination temperature on the germination of *Betula nana*. Plant Physiol., **23,** 425—433.

KATSUMI, M. (1971): Biological activities of gibberellins and their glucosides in *Pharbitis nil*. Phytochem., **10,** 2943—2949.

KATSUMI, M. (1973): Biological activities of new gibberellins A_{30-35} and A_{35} glucoside. Phytochem., **12,** 255—261.

KENTZER, T. (1966): Gibberellin-like substances and growth inhibitors in relation to the dormancy and after-ripening of ash seed (*Fraxinus excelsior* L.). Acta Soc. Bot. Pol., **35,** 575—582.

Knöfel, H. D.—Müller, P.—Kramell, R.—Sembdner, G. (1975): Preparation of gibberellin affinity absorbents. Febs Letters, **60**, 39—41.
Konjevič, R.—Grubišič, D.—Markovič, R.—Petrovič, J. (1976): Gibberellic acid-binding proteins from pea stems. Planta, **131**, 125—129.
Kopcewicz, J.—Porazinski, Z. (1973): Influence of low temperature on germination and endogenous growth regulator contents in scots pine (*Pinus silvestris* L.) seeds. Acta Soc. Bot. Pol., **43**, 233—240.
Lang, A. (1970): Gibberellins: Structure and metabolism. Ann. Rev. Plant Physiol., **21**, 537—571.
McComb, I. (1961): "Bound" gibberellin in mature runner bean seed. Nature, **192**, 575—576.
Musgrave, A.—Kays, S. E.—Kende, H. (1972): Uptake and metabolism of radioactive gibberellins by barley aleurone layers. Planta, **102**, 1—10.
Nadeau, R. L.—Rappaport, L.—Stolp, C. F. (1972): Uptake and metabolism of ^{3}H-gibberellin-A_1 by barley aleurone layers: response to abscisic acid. Planta, **107**, 315—324.
Nagy, M.—Szalai, I. (1973): Dormancy in fruits of *Tilia platyphyllos* Scop. I. Acta Biol. Szeged, **19**, 71—77.
Reeve, D. R. (1974): An assessment of gibberellin structure-activity relationships. J. Exp. Bot., **85**, 431—445.
Reinhard, E.—Konopka, W.—Sacher, R. (1964): Zur Trennung der Gibberelline in Pflanzenextracten mit Hilfe der Dünnschichtchromatographie und der horizontaler Säulenchromatographie. J. Chromatog., **16**, 99—103.
Reinhard, E.—Sacher, R. (1967): Versuche zum enzimatischen Abbau der gebundenen Gibberelline von *Pharbitis purpurea*. Experientia, **23**, 415—416.
Ross, J. D.—Bradbeer, J. W. (1968): Concentrations of gibberellin in chilled hazel seeds. Nature, **220**, 85—86.
Ross, J. D.—Bradbeer, J. W. (1971): Studies in seed dormancy V. The content of endogenous gibberellins in seeds of *Corylus avellana* L. Planta, **100**, 288—302.
Sembdner, G.—Borgman, E.—Schneider, G.—Liebisch, H. W.—Miersch, O.—Adam, G.—Lischewski, L.—Schreiber, K. (1976): Biological activity of some conjugated gibberellins. Planta, **132**, 249—257.
Sembdner, G.—Weiland, J.—Aurich, O.—Schreiber, K. (1968): Isolation, structure and metabolism of a gibberellin glucoside. In: Plant growth regulators. Soc. Chem. Ind. Monogr., **31**, 70—86.
Sinska, I.—Lewak, S. (1970): Apple seed gibberellins. Physiol. Veg. Paris, **8**, 661—667.
Stoddart, J.—Breidenbach, W.—Nadeau, R.—Rappaport, L. (1974): Selective binding of ^{3}H gibberellin A_1 by protein fractions from dwarf pea epicotyls. Proc. Nat. Acad. Sci. (USA), **71**, 3255—3259.
Szalai, I.—Nagy, M. (1968): The causes of dormancy in *Fraxinus excelsior* L. fruits and the role of gibberellic acid in breaking dormancy. III. The stimulative and inhibiting substances of the fruits. Acta Bot. Acad. Sci. Hung., **14**, 415—423.
Szalai, I.—Nagy, M. (1974): Dormancy in fruits of *Tilia platyphyllos* Scop. II. The inhibitor-substance content of dormant fruits. Acta Bot. Acad. Sci. Hung., **20**, 389—394.
Tomasewska, E. (1976): Growth regulators in norway maple (*Acer pseudoplatanus* L.) seeds. Arboretum Kórnickie, **21**, 297—312.
Yokota, T.—Takahashi, N.—Murofushi, N.—Tamura, S. (1969): Isolation of gibberellins A_{26} and A_{27} and their glucosides from immature seeds of *Pharbitis nil*. Planta, **87**, 180—184.

Acta Agronomica Academiae Scientiarum Hungaricae, Tomus 29 (1—2), pp. 13—23 (1980)

FITTING AND GENETIC ANALYSIS OF GROWTH CURVES FOR YOUNG BULLS

By

L. TELEGDI, B. B. ANDERSEN, I. THYSEN

COMPUTER AND AUTOMATION INSTITUTE OF THE HUNGARIAN ACADEMY OF SCIENCES, BUDAPEST; NATIONAL INSTITUTE OF ANIMAL SCIENCE, COPENHAGEN

In order to analyse the beef production of young bulls, the authors considered the possibilities of describing the course of the weight growth for individually tested animals. On the basis of the growth functions obtained, analysis of the overall phenotypical standard deviation and the within-breed coefficient of heritability of the function parameters and their relationship to rate of growth, feed utilization, rate of maturing and mature size were performed. The results of these analysis are given in six tables. In Tables 1 and 2 one can read the average, the standard deviation and the coefficient of heritability, in Tables 3 and 4 the effect of breed on these factors, and in Tables 5 and 6 the phenotypical and genetic correlations between them and the production traits. Several weight/age functions have been suggested for characterizing the growth of various species. The authors chose the simple logistic function and one of its generalizations. These were fitted by means of the least squares method as described by HARTLEY (1961). This iterative procedure converged rapidly for both functions, and the generalized function in particular gave a very accurate description of the growth. The authors suggest that each bull might have three specific values of age, Dt, t_1 and t_2, with the following properties: Dt is the age at the inflection point; $t_1 = 2 \cdot Dt < t_2$; in $[0, t_1]$ the weight growth is described most extensively by the simple logistic function, in $[0, t_2]$ by the generalized one, and after t_2 by the negative exponential function. The technique used provides an effective method of describing individual growth patterns, which are very useful for simulating studies of the optimum slaughter weight of different breed groups, etc. On the other hand, as the parameters of the generalized logistic function are only determined to a slight extent genetically and are correlated to the most important production traits it is not really worth-while including these parameters in a performance test selection.

Introduction

In agriculture a frequent type of question demanding mathematical analysis is how to describe the development in time of utility traits of domestic animals. Characteristic tasks related to this are investigations into the genetic determination of the parameters of this development and the qualification of individuals on the occasion of performance test selection. A theoretical method for the description in time which will also be useful in practice has still to be developed. To this end attention must be paid to the number. time and accuracy of measurements, as well as to knowledge concerning hereditary and environmental features and the most important quantitative empirical characteristics of the utility trait under consideration. The purpose of the description imposes further constraints on the set of models and calculations. The validity of the description prepared on these principles can be verified by comparing the experimental data and/or the most important characteristics of the utility trait computed on the basis of the data with their estimates given by the description.

In order to analyse the beef production of young bulls, an examination has been made of how the live weight of individually tested animals changes as a function of age. The functions obtained in this way described mathematically the weight growth of the bulls from the first weighing until slaughter. The genetic variation of these functions and the relationship between them and other, economically important beef production traits has been investigated. Our investigations centred around the following four questions:

1) By what kinds of mathematical methods can the growth functions be determined?
2) What are the growth functions like and what parameters do they have?
3) What is the genetic variation and heritability of these parameters?
4) What connections do the parameters have with certain important characteristics of beef production?

The first two questions being in close connection, they were answered simultaneously. The other two questions were dealt with later.

Material and Method

The data used for the calculations were divided into the following two groups:

1) *Datagroup A:* Records of weighing, feed consumption and carcass composition were collected on 1,011 young bulls from the progeny test for beef production at the Egtved breeding station. These young bulls were distributed in 136 progeny groups of the breeds Danish Red (RDM), Black Pied Danish (SDM) and Danish Red and White (DRK). The bull calves were born in the months of January and February in the years 1967 to 1971. When 15 days old the test was started in the station and the calves were fed with restricted amounts of skim-milk and hay and as much concentrate as they could eat. All the feed was weighed out to each animal individually. The bulls were weighed at the beginning of the test, at the age of 42 days and then at 28 days intervals, until slaughter at a constant weight of 450 kg. (For further details, see Andersen 1977.)

2) *Datagroup B:* Records of weighing, feed consumption and carcass composition were collected for young bulls from a beef × dairy crossbreeding experiment in which sires of the breeds Simmental (SIM), Charolais (CHAR), Danish Red and White (DRK), Romagnola (ROM), Chianina (CHI), Hereford (HER), Blonde d'Aquitaine (BDA) and Limousin (LIM) were crossed with Red Danish and Black Pied Danish cows. The bull calves were born in the months of October, November and December in 1972, 1973 and 1974, and when they reached the age of 15 to 25 days the test was started at the Egtved breeding station. The feeding regime consisted of skim-milk and hay according to age and as much concentrate as they could eat. All the feed was weighed out to each animal individually. The bulls were weighed on arrival at the station, at the age of 28 and 42 days and then at 28 days intervals. The calves were divided into two groups and slaughtered at a constant age of 12 and 15 months, respectively. Details of the experimental design are given by Andersen *et al.* (1976) and Liboriussen (1977).

In both datagroups the feed intake was individually controlled. After slaughter the carcasses were dissected by the Meat Research Institute in Roskilde.

A common method suitable for curve fitting is the least squares method. If one wants to fit a function to the experimental data of a utility trait without having data throughout the whole period where this utility trait can systematically change (as in our case), there is always a risk that the extrapolated values of the function obtained by means of the least squares fitting do not correspond to the real development of the animal under consideration. In this case, if one needs such extrapolated values, the task of curve fitting can be solved by means of the so-called general loss function, i.e. by minimizing a weighted quadratic average of deviations of the most important characteristics of the utility trait computed on the basis of the data from their estimates derived from the curve (see FISCHER *et al.* 1974).

In our case, the weight growth of the individual bulls was mathematically described by the simple logistic function

$$y = \frac{a}{1 + be^{-ct}} \tag{1}$$

and its modification

$$y = \frac{a}{1 + be^{-ct}} - d, \tag{2}$$

where y is the weight in kg at the age of t days. The estimated values of the birth weight and the mature weight given by the least squares functions of these forms were too small. There is a reason for the first bias here which means it cannot be eliminated by other methods either (the development of the animals slows down on arrival at the test station). On the other hand, the bulls in question were slaughtered before reaching their final weight and the performance tests, the tests for breed comparison, etc. are usually based on this period, where the average error of the least squares functions is in most cases fairly small. Therefore we finally chose the least squares method.

For the statistical analysis the following production traits were calculated from the data:

First weight (kg):	y_1
Age at first weighing (days):	m
Birth weight (kg):	$y_1 - 0.4 \cdot m$
Final weight (kg):	F
Number of days in test:	n
Carcass weight (kg):	CW
Daily gain (g/day):	$1000 \cdot (F - y_1)/n$
Carcass gain (g/day):	$1000 \cdot (CW - 0.5 \cdot y_1)/n$
Dressing percentage (%):	$100 \cdot CW/F$
Total feed consumption (Scand. f. u.):	SFU
Feed utilization (Scand. f. u./kg gain):	$SFU/(F - y_1)$
Weight of lean in right side of the carcass (kg):	LW
Percentage lean:	$100 \cdot LW/(0.5 \cdot CW)$
Weight of bone in right side of the carcass (kg):	BW
Weight of fat in right side of the carcass (kg):	FW
Weight of lean in the pistol (kg):	WPL
Lean/bone ratio:	LW/BW
Lean/fat ratio:	LW/FW
Pistol lean/total lean:	WPL/LW

For the description of the genetic variation and heritability of the growth function parameters and their relationship with the production traits, the following models were used for the statistical analysis:

$$Y_{ijk} = \mu + a_i + b_j + d_k \text{ (datagroup B)},$$

$$Y_{ijk} = \mu + (ab)_i + s_{ij} + e_{ijk} \text{ (datagroup A)},$$

where

Y = individual performance,
μ = population mean,
a_i = effect of year i,
$(ab)_i$ = effect of year · breed i,
b_j = effect of sirebreed j,
d_k = effect of dambreed k,
s_{ij} = effect of sire j nested within year · breed i,
e = error term.

The different effects are assumed to be independent, normally distributed random variables with mean zero, and interactions are pooled with the error term, because preliminary considerations showed their unimportance. On the basis of these models, LSMLMM programmes (see HARVEY 1972) were used.

The computer programmes were written in FORTRAN IV and developed on the IBM 370/165 machine of the Northern Europe University Computing Center (NEUCC).

Results

The most important criterion for judging the goodness of fitting a growth function to experimental data of a utility trait is a comparison of the data and/or the most important characteristics of the trait computed on the basis of the data with their estimates derived from the growth function animal by animal. However, if the number of data of some one animal is n, one can always fit, for instance, a polynomial of degree $(n - 1)$ in such a way that the deviations of the data from their estimates will be zero. On the other hand, when doing this for a comparatively homogeneous group of animals, the standard deviation of the coefficients of the polynomial will be groundlessly high. Two other factors must also be taken into consideration. These are the following:

1) The form of the function, and thus the growth mechanism corresponding to it, must be reasonable and interpretable biologically.

2) One must be able to fit the function by means of appropriate mathematical and computational methods which do not take too much computing time.

In practice, several functions are used to describe growth mathematically (see, for example, BRODY 1945, KRETSCHMANN—WINGERT 1971, MARUBINI 1975). In various species, including cattle, the increase in weight accelerates during the period after birth, after which the rate of growth declines until reaching the final weight. In such cases the weight growth is characterized very extensively by logistic, so-called sigmoid functions. EISEN *et al.* (1969) give a general comparison of the simple logistic function with other, non-logistic growth functions. Their results, other reports and our preliminary calculations suggested that although the conclusions reached by means of the different functions may be fairly similar, in our case the best description is given by some kind of logistic function.

One reason for applying a generalized logistic function as well is the fact that the estimated live weight $\widehat{Dy}$ at maximum weight growth (at the inflection point) derived from (1) is exactly half the estimated mature weight $\hat{y}_{\max}$ derived again from (1), i.e.

$$\widehat{Dy} = \frac{\hat{y}_{\max}}{2} .$$

This is not realistic for the development of cattle. Therefore we tried to characterize the growth of the individual animals by means of (2) as well. As far

Table 1

Average, standard deviation and coefficient of heritability for various growth function parameters (datagroup A)

	Average	SD	$h^2 \pm$ s.e.
A3	515.3	37.2	0.16 0.09
A4	726.8	233.9	0.10 0.08
B3	10.55	1.13	0.31 0.10
B4	5.92	1.83	0.18 0.09
C3	0.00757	0.00062	0.21 0.09
C4	0.00743	0.00182	0.18 0.09
D4	89.0	82.6	0.06 0.08
DX3	210.2	18.0	0.24 0.09
DX4	223.1	41.2	0.24 0.09
DY3	257.6	18.6	0.16 0.09
DY4	274.4	52.6	0.20 0.09
BW	31.4	5.64	0.60 0.12
AW	637.8	161.5	0.13 0.08

Table 2

Average and standard deviation for various parameters of growth function (2) (datagroup B)

	Average	SD
A4	631.1	99.6
B4	11.7	7.2
C4	0.0097	0.0025
D4	23.6	38.6
DX4	231.2	21.0
DY4	291.9	26.9
BW	39.7	10.5
AW	607.5	70.1

as its application to the live weight growth of lambs, chickens and bulls is concerned, the reader is referred to FISCHER *et al.* (1974), LILJEDAHL (1970, 1975). LILJEDAHL writes (2) in the form

$$y = \frac{A + Be^{\lambda t}}{1 + Ce^{\lambda t}},$$

where $A = a - d$, $B = -bd$, $C = b$ and $\lambda = -c$.

Table 3

Effect of breed on various growth function parameters (datagroup A)

	RDM	SDM	DRK	F-value
A3	514.6	515.7	520.4	0.7
A4	720.3	733.7	763.0	1.2
B3	10.6	10.5	10.5	1.9
B4	5.99	5.81	5.94	1.7
C3	0.00751	0.00766	0.00761	7.2
C4	0.00741	0.00747	0.00722	0.6
D4	87.4	91.8	91.7	0.5
DX3	212.5	207.1	208.6	12.1
DX4	224.7	219.7	230.8	2.6
DY3	257.3	257.9	260.2	0.7
DY4	272.7	275.0	289.8	2.6
BW	31.3	31.3	32.2	0.6
AW	632.8	641.9	671.2	1.7

By introducing d, we obtain that

$$\widehat{Dy} = \frac{\hat{y}_{\max}}{2} - \frac{d}{2}.$$

The modification is evident also theoretically, because it means the combination of the well-known growth mechanisms represented by the negative exponential function

$$y = a - be^{-ct} \tag{3}$$

Table 4

Effect of sirebreed on various parameters

	SIM	CHAR	DRK	ROM
A4	632.0	636.9	694.6	608.2
B4	10.8	11.0	8.4	14.7
C4	0.0096	0.0096	0.0082	0.0103
D4	35.6	13.4	43.1	2.3
DX4	220.9	231.8	236.2	238.2
DY4	280.3	305.1	304.2	301.8
BW	36.3	46.3	39.9	46.0
AW	596.4	623.5	651.5	605.9

(for its application to cattle see, for example, BROWN *et al.* 1972) with (1), since the differential equations corresponding to (3) and (1) are

$$\frac{dy}{dt} = K_1(K_2 - y) \tag{4}$$

and

$$\frac{dy}{dt} = L_1 y(L_2 - y)\,, \tag{5}$$

where K_1, K_2, L_1 and L_2 are constant values and the differential equation corresponding to (2) is

$$\frac{dy}{dt} = F(y)\,,$$

where the expression $F(y)$ is the weighted sum of the right sides of (4) and (5). The iterative procedure used after HARTLEY (1961) for functions (1) and (2) converged rapidly: the fitting of the 1,011 growth functions (1) in datagroup A, for instance, took less than 1.5 minutes; the fitting of functions (2) in datagroup A took about the same computing time. For the functions (1) and (2) used in datagroup A, the average standard deviations between the calculated and actual weight/age values were 5.9 and 3.5 kg respectively. This shows that the two logistic functions, especially the generalized one, give a very accurate description of the weight growth of young bulls during the period from which the data were obtained.

In the literature other generalized logistic functions can also be found (see the above-mentioned references). However, at least one of the aforesaid problems, namely, (i) its form is too complicated and not reasonable biologically, (ii) the standard deviation of the parameters is very great, or (iii) the fitting of the function takes too much computing time, arises in each case.

of growth function (2) (datagroup B)

	CHI	HER	BDA	LIM	F-value
A4	574.5	629.9	616.5	633.8	0.9
B4	13.9	11.7	18.1	8.9	1.1
C4	0.0107	0.0099	0.0110	0.0092	0.8
D4	4.6	28.0	23.9	31.6	1.1
DX4	234.8	230.8	221.8	229.9	0.6
DY4	282.7	286.9	284.4	285.2	1.2
BW	40.7	35.7	39.9	33.9	1.5
AW	569.9	601.9	592.6	602.2	0.9

Table 5

Phenotypical and genetic correlations between parameters of growth function (2) and selected production traits (datagroup A)

		A4	B4	C4	DX4	DY4	BW	AW
Birth weight	r_P	0.06	0.04	0.02	0.03	0.20	0.82	0.18
	r_G	—0.51 ± 0.32	0.42 ± 0.23	0.59 ± 0.23	—0.48 ± 0.21	—0.19 ± 0.22	0.97 ± 0.02	—0.48 ± 0.21
Daily gain	r_P	0.11	0.11	0.05	0.06	0.31	0.25	0.18
	r_G	—0.12 ± 0.33	0.60 ± 0.25	0.41 ± 0.26	—0.16 ± 0.23	0.23 ± 0.24	0.35 ± 0.16	0.03 ± 0.30
Carcass gain	r_P	0.06	0.10	0.08	—0.01	0.23	0.23	0.12
	r_G	0.00 ± 0.38	0.51 ± 0.28	0.22 ± 0.29	—0.02 ± 0.27	0.30 ± 0.27	0.41 ± 0.18	0.13 ± 0.33
Dressing percentage	r_P	—0.11	—0.01	0.07	—0.14	—0.17	—0.08	—0.13
	r_G	0.27 ± 0.33	—0.36 ± 0.24	—0.46 ± 0.23	0.29 ± 0.22	0.06 ± 0.23	—0.09 ± 0.16	0.19 ± 0.28
Percentage lean	r_P	0.13	—0.16	—0.13	—0.02	0.07	0.05	0.11
	r_G	—0.29 ± 0.32	0.30 ± 0.25	0.38 ± 0.24	—0.06 ± 0.22	0.08 ± 0.24	0.38 ± 0.15	—0.14 ± 0.28
Lean/fat	r_P	0.11	—0.15	—0.10	—0.03	0.07	0.12	0.10
	r_G	—0.56 ± 0.35	0.50 ± 0.24	0.59 ± 0.23	—0.21 ± 0.22	0.01 ± 0.23	0.48 ± 0.14	—0.33 ± 0.28
Lean/bone	r_P	0.07	—0.10	—0.09	—0.01	—0.03	—0.11	0.05
	r_G	0.23 ± 0.31	—0.17 ± 0.25	—0.14 ± 0.24	0.20 ± 0.22	0.11 ± 0.23	—0.03 ± 0.16	0.19 ± 0.27
Pistol lean/total lean	r_P	0.01	—0.02	0.02	—0.06	0.02	0.19	0.02
	r_G	—0.32 ± 0.32	0.60 ± 0.25	0.56 ± 0.25	—0.16 ± 0.22	0.02 ± 0.24	0.61 ± 0.14	—0.19 ± 0.28
Fad utilization	r_P	—0.18	—0.20	—0.09	—0.10	—0.32	—0.30	—0.17
	r_G	0.24 ± 0.34	—0.73 ± 0.29	—0.52 ± 0.26	0.13 ± 0.23	—0.25 ± 0.27	—0.43 ± 0.18	0.04 ± 0.29

In (2), the parameters may be interpreted biologically (this is the main reason why we do not use Liljedahl's form). Let $\hat{y}_0$ and $\widehat{Dt}$ be the estimated values of the birth weight and the age at the inflection point. We obtain that from among the parameters of (2)

$$a = 2(\hat{y}_{\max} - \widehat{Dy}) , \qquad a = 2\left(\frac{\hat{y}_{\max}}{2} - \widehat{Dy}\right),$$

$$b = \frac{\hat{y}_{\max} - \hat{y}_0}{(\hat{y}_{\max} - \widehat{Dy}) - (\widehat{Dy} - \hat{y})} . \tag{6}$$

The explicit expression for c is more complicated. In fact, c is characteristic of the growth rhythm.

On the basis of our studies of individual growth curves it is suggested that each bull might have two specific values of age $t_1 < t_2$ with the following properties: $t_1 = 2 \cdot Dt$ (Dt is the age at the inflection); in the age interval $[0, t_1]$ the weight growth is described most extensively by function (1), in the age interval $[0, t_2]$ by function (2), and after age t_2 by function (3). For most of the bulls in the two datagroups the values t_1, t_2 were such that $t_1 <$ slaughter age $< t_2$. However, several of the bulls in datagroup B slaughtered at 12 months seem to have a t_1 value greater than 12 months. It was therefore decided to choose both logistic functions for further analysis.

The results of the analysis of the overall phenotypical standard deviation and the within-breed coefficient of heritability of the growth function parameters and their relationship to production traits are presented in Tables 1—6. Here we use the following notations:

		Function (1)	Function (2)
Derived value of	a	A3	A4
	b	B3	B4
	c	C3	C4
	d	—	D4
	Dt	DX3	DX4
	Dy	DY3	DY4
	y_0	—	BW
	$y_{\max}$	—	AW

The parameters of the individual growth functions (2) generally show a large standard deviation (Tables 1 and 2). However, this seems to be only to a slight extent genetically determined, since although the age at the point of inflection seems to have an important genetic variation and the calculated birth weight is strongly hereditary, the other coefficients of heritability have low values.

Table 6

Phenotypical correlations between parameters of growth function (2) and selected production traits (datagroup B)

	A4	B4	C4	DX4	DY4	BW	AW
Birth weight	—0.04	0.20	0.19	—0.03	0.41	0.86	0.13
Daily gain	0.17	—0.02	0.03	0.02	0.54	0.24	0.33
Percentage lean	—0.07	0.09	0.09	—0.18	—0.04	0.11	—0.07
Lean/fat	—0.14	0.17	0.16	—0.22	—0.12	0.14	—0.14
Lean/bone	0.24	—0.17	—0.20	—0.02	0.11	—0.13	—0.22
Pistol lean/total lean	—0.38	0.28	0.31	—0.10	—0.26	0.19	—0.37
Feed utilization	0.70	—0.65	—0.69	0.28	0.39	—0.38	0.64

In Tables 3 and 4 the effect of bread is demonstrated. Among the three Danish dual purpose cattle breeds the SDM has the lowest *Dt* value and tends to be the earliest developed breed. In the beef $\times$ dairy crossbreeding experiment the calculated mature weight is lowest for Chianina crosses and highest for DRK crosses.

As demonstrated in Table 5, the parameter A4 tends to be correlated negatively to actual birth weight and lean/fat ratio, *B4* positively to daily gain, carcass gain, lean/fat and pistol lean/total lean ratios and negatively to feed utilization, and *C4* positively to actual birth weight and the previous ratios and negatively to feed utilization. The calculated birth weight is positively correlated, apart from the birth weight, to pistol lean/total lean ratio, and also, not so strongly, to daily gain, carcass gain, percentage lean and lean/fat ratio and negatively to feed utilization.

In general, however, the correlations between the function parameters and the most important production traits are very low.

From the results obtained it may be concluded that the technique used provides an effective method of describing individual growth patterns, which is very useful for simulation studies of the optimum slaughter weight of different breed groups, etc. However, in performance tests on young bulls and in breed evaluation experiments it is not possible to predict the maturing rate and the mature weight of the genotype from a 1 to 12 months' test.

References

ANDERSEN, B. B. (1977): Genetic investigations on growth, body development and feed utilization in dual purpose cattle. Report No. 488. National Institute of Animal Science, Copenhagen.

ANDERSEN, B. B.—LIBORIUSSEN, T.—THYSEN, I.—KOUSGAARD, K.—BUCHTER, L. (1976): Crossbreeding experiment with beef- and dual purpose sire breeds on Danish dairy cows. Liv. Proc. Sci., **3**, 227—238.

BRODY, S. (1945): Bioenergetics and growth. Hafner, New York.

BROWN, J. E.—BROWN, C. J.—BUTTS, W. T. (1972): A discussion of the genetic aspects of weight, mature weight and rate of maturing in Hereford and Angus cattle. J. Animal Sci., **34**, 525—537.

EISEN, E. J.—LANG, B. J.—LEGATES, J. E. (1969): Comparison of growth functions within and between lines of mice selected for large and small body weight. Theoret. Appl. Genetics, **39**, 251—260.

FISCHER, J.—TELEGDI, L.—CSUKÁS, E. (1974): A new method of stochastic prediction based on growth curves (in Hungarian). Mérés és Aut., **22**, 212—215.

HARTLEY, H. O. (1961): The modified Gauss—Newton method. Technometrics, **3**, 269—280.

HARVEY, W. R. (1972): Instructions for use of LSMLMM. Ohio State Univ.

KRETSCHMANN, H. J.—WINGERT, F. (1971): Computeranwendungen bei Wachstumsproblemen in Biologie und Medizin. Springer, Berlin.

LIBORIUSSEN, T. (1977): Beef crossbreeding in SDM and RDM. A comparative study of the suitability of eight beef- and dual purpose breeds. Diss. Copenhagen.

LILJEDAHL, L. E. (1970): A study on the course of growth in broiler chickens. Acta Agric. Scand., **20**, 249—256.

LILJEDAHL, L. E. (1975): Growth parameters and their genetic determination in young bulls. Acta Agric. Scand., **25**, 42—48.

MARUBINI, E. (1975): Models and methods for human growth and development problems. In: L. C. A. Corsten—T. Postelnicu (editors): Proceedings of the 8th International Biometric Conference, 163—173. Editura Academiei, Bucuresti.

Acta Agronomica Academiae Scientiarum Hungaricae, Tomus 29 (1—2), pp. 25—37 (1980)

THE OCCURRENCE OF DIFFERENT TYPES OF CALCIUM OXALATE CRYSTALS IN ALLIUM CEPA L. AND ALLIUM FISTULOSUM L. AND THEIR IMPORTANCE IN TAXONOMY

By

S. K. SARMA, A. TERPÓ

DEPARTMENT OF BOTANY, UNIVERSITY OF HORTICULTURE. BUDAPEST

The calcium oxalate crystals found in the dry scale leaves of *Allium cepa* and *Allium fistulosum* revealed some interesting features. When for the study the dry scale leaves were divided into four arbitrary zones, namely 1) lowermost, 2) lower middle, 3) upper middle and 4) uppermost, the maximum amount of crystals in *A. cepa* scale leaves was found in the lowermost zone, followed by the uppermost, the lower middle and the upper middle zone. This sequence of crystal distribution was found to be slightly altered in *A. fistulosum*. At least seventeen different types of crystals were found in both species, some of which were not reported earlier from these species. The pattern of distribution of the crystals is also different in the different zones. For example, they are arranged in rows in some zones whereas in others they are scattered. An interesting marking, described here as the "central body", is found in many crystals of both species. Their occurrence is also specific to a particular zone of the leaves. Though many different types of crystals were found in both species, only a few types were found to be abundant, which may again be specific to a particular zone of the leaf. The same crystal types in *A. cepa* were found to be longer and broader than those in *A. fistulosum*.

Introduction

During the process of metabolism, the plants synthesise different types of chemical substances, namely alkaloids, flavanoids, terpenoids, starch grains, raphides, solitary crystals, etc. The presence of these substances in particular types of plants is found to have some taxonomical value. Many authors have studied the taxonomical importance of alkaloids, flavanoids, terpenoids, etc.

In the present study, some important features of the calcium oxalate crystals found in the dry scale leaves of *A. cepa* and *A. fistulosum* are described and their taxonomical importance discussed.

Authors (HEGNAUER 1963, DENFFNER 1971, FROHNE—JENSEN 1973) have studied calcium oxalate crystals, which are widespread in the plant kingdom. The crystals arise either as monohydrates, $Ca(C_2O_4) \cdot 1\, H_2O$, or dihydrates, $Ca(C_2O_4) \cdot 2\, H_2O$. The calcium oxalate monohydrate crystals fall under the monoclinic system of crystal classification while the dihydrate crystals are grouped under the tetragonal system. JACCARD—FREY (1928) and KÜSTER (1956) reported that calcium oxalate crystals are found to occur both in permanent and meristematic tissues and their structures have taxonomical values mainly at the level of the genus. According to ESAU (1965) calcium oxalate crystals may be commonly observed in vacuoles. Others however reported that crystals are formed in the cytoplasm (SCOTT 1941). Some oxalate crystals arise in cells that resemble adjacent, crystal-free cells. Sometimes they are formed in specialised cells, the idioblasts, which are markedly different from other constituents of the same tissue in form, structure, etc. (ESAU 1965).

Very few records have been found of the taxonomic significance of the crystals found in plant parts. JACCARD—FREY (1928) described the calcium oxalate crystals of some species of the genus *Allium*, including *A. cepa* and *A. fistulosum*, where they suggested that particular types of crystals were characteristic of a species. They also mentioned the results of Sachs and Klebs: the latter authors found calcium oxalate crystals even in two-week-old onion seedlings. SCOTT (1941) studied the calcium oxalate crystals present in *Ricinus communis* and found some relation between the presence of crystals and the deposition of ergastic substances. He reported that in plant parts where there is more starch deposition, the presence of crystals in that part is less frequent or absent altogether. GIBBS (1958) notes that the ability to store calcium oxalate in bundles, i.e. raphides, appears to be restricted to certain groups of plants and may therefore have some value as evidence of relationship. DORMER (1961) has studied the crystals which are to be found in the inner tissues of the ovary wall of many Compositae. In his opinion they contain varieties of crystals, some of which have a restricted systematic distribution. In his study of the *Cynareae* his results suggest that these characters may be of considerable taxonomic value. Again in the genus *Centaurea*, DORMER (1962) found that prismatic or curvilinear crystal structure cuts across the conventional classification of the genus, but shows quite a close correlation with pollen types. HEGNAUER (1963) described the phytochemistry of about 300 species of *Allium*, including the calcium oxalate crystals. In his opinion the occurrence and shape of the crystals of the species of *Allium* have great taxonomical value. AL-RAIS *et al.* (1971) reported the isolation and properties of calcium oxalate crystals from some angiospermous plants. According to the presence or absence of crystals the plants examined have been classified into different groups. RAKOVÁN *et al.* (1973) studied the cytomorphological aspects of crystal formation in the aerial root of *Monstera deliciosa* Liebm., where they found that the process of crystal formation begins in the cytoplasm. They have also observed calcium oxalate crystals in rows between the membrane pairs in the growing idioblasts and even in the cytoplasm. TERPÓ—SARMA (1977) described the calcium oxalate crystals of *A. cepa* and discussed their taxonomical significance.

Materials and Methods

Crystals have been studied from fifty cultivars of *A. cepa* and two varieties of *A. fistulosum*. In order to study the crystals, five bulbs were selected from each cultivar or variety of both the species and one entire thin dry scale leaf was removed from each bulb. The leaves were dipped in absolute alcohol and kept in it for a week. When examining the crystals, each leaf was divided into four zones (Fig. 1):

1) lowermost zone,
2) lower middle zone,
3) upper middle zone,
4) uppermost zone.

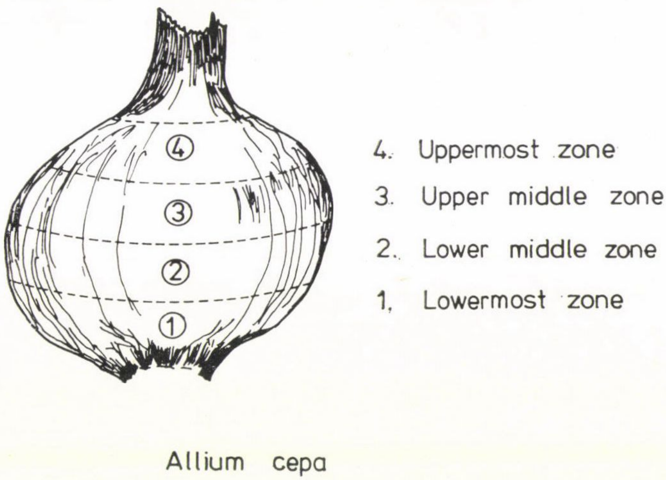


Fig. 1. Dry scale leaf of *Allium cepa* divided into four arbitrary zones

From each of the above zones a small portion (about one cm^2) was cut out and mounted in 50% glycerine. Since staining was of no noticeable value, no stain was added. The crystals were examined under 10×8 and 10×40 magnifications with a laboratory microscope. The pattern of distribution of the crystals, i.e. whether they are in rows or are scattered, was examined under 10×8 magnification for different zones of the leaves. Other measurements, such as counts of crystals per unit area, abundant crystal types, and length and breadth of the crystals, were made under 10×40 magnification. The unit area used in counting the number of crystals was the microscopic field under 10×40 magnification. The abundant types of crystals present in a particular zone were noted. Also the presence of different types of crystals was noted. Since the more abundant and bigger crystals were of types A and D (Fig. 2), the measurements of length and breadth were only taken for these two types of crystals for every cultivar and variety of both the species. This measurement was made from the crystals of the lower middle zone of all the leaves. The presence of a "central body", a marking which is present in many crystals, was also noted. In every case five measurements were taken and their mean was calculated.

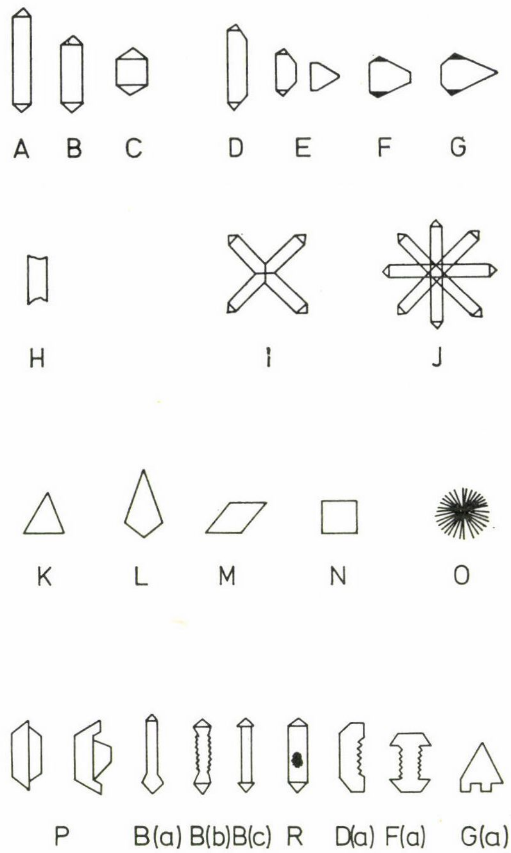


Fig. 2. Different types of crystals of *Allium cepa* and *A. fistulosum* (Diagrammatic)

Results

The available chemical evidence suggest that the crystals found in the dry scale leaves of ***Allium cepa*** and ***A. fistulosum*** consist of calcium oxalate. Most of these crystals are solitary, while they are occasionally found in groups and are found to be present inside the cells or even scattered over the cell walls. During the study, different types of crystals were found, most of which were not reported earlier either in ***A. cepa*** or in ***A. fistulosum***. Most of these crystals fall into the tetragonal system of crystal classification while a few are grouped under the monoclinic system and the regular system. The different types of crystals found in the dry scale leaves of ***A. cepa*** and ***A. fistulosum*** were as follows (Fig. 2):

I. Tetragonal system

1. In bipyramidal and prismatic combinations (the prismatic sides are rectangular or square in outline; parallel sides are of equal length).

Type A: Long, narrow (elongated), bipyramidal + prismatic, sides are rectangular.

Type B: Long, broad, bipyramidal + prismatic, sides are rectangular.

Type C: Thick, short, bipyramidal + prismatic, sides are square. So far reported only in *A. sativum* (JACCARD—FREY 1928).

2. In bipyramidal and prismatic combinations (the parallel sides are of unequal length).

Type D: Long, prismatic, with unequal sides. So far reported only in *A. oleraceum* (JACCARD—FREY 1928) and in *A. sativum* (FREY 1929).

Type E: Short, prismatic, with unequal sides. So far known only in *A. oleraceum* (JACCARD—FREY 1928) and in *A. sativum* (FREY 1929).

Type F: Short, thick, isodiametric, with unequal sides. So far reported only in *A. oleraceum* (JACCARD—FREY 1928).

Type G: Short, thick, isodiametric, pentagonal. So far known only in *A. oleraceum* (JACCARD—FREY 1928).

3. Open crystals.

Type H: Prismatic, open type. So far reported only in *A. schoenoprasum* (JACCARD—FREY 1928).

4. Twin crystals.

Type I: Simple twin crystal.

Type J: Aggregated (twin) crystal. So far reported only in *A. sphaerocephalum* (JACCARD—FREY 1928).

5. Triangular crystal.

Type K: Three sided or triangular crystal. Not reported so far in *Allium.*

6. Deltoid crystal.

Type L: Deltoid crystal of doubtful position. So far not reported in *Allium.*

7. Rhomboid crystal.

Type M: Rhomboid crystal. Not reported so far in *Allium.*

II. Regular system

8. *Type N:* Cuboid crystal.

III. Monoclinic system

9. *Type O:* Sphaerocrystal. Sphaerocrystals and crystals of the monoclinic system have not been reported so far in *A. cepa.*

10. Crystals of doubtful position (and system).

Type P: Most probably twin crystals.

The crystals in the dry scale leaves of *A. cepa* and *A. fistulosum* were found to be present in an orderly manner from the base towards the apex of the leaf. In *A. cepa* the maximum amount of crystals was found to be present in the lowermost zone, followed by the uppermost, lower middle and upper middle zones (Fig. 3). This pattern of distribution was constant in all the cultivars of *A. cepa.* The distribution of the crystals in different zones of the scale leaves of *A. cepa* was as follows (Fig. 4a):

1) lowermost zone = 39%,
2) lower middle zone = 19%,
3) upper middle zone = 16.5%,
4) uppermost zone = 25.5%.

The state of distribution of the crystals, i.e. whether they occur in rows or are scattered, is different in the different zones of the leaves. In *A. cepa* in the lowermost zone they are always scattered and are never present in line or in rows. In most of the cultivars of *A. cepa* examined, the crystals were in line or in rows in the upper middle zone (Fig. 6) followed by the uppermost and the lower middle zone. In 40% of the cultivars studied the crystals were in line in the upper middle zone. This is followed by the uppermost (34%), and the lower middle zone (22%) (Fig. 4b).

The distribution of crystals in the four different zones of the scale leaves of *A. fistulosum* showed little variation from those of *A. cepa*, and is as follows (Fig. 5):

1) lowermost zone = 38%,
2) lower middle zone = 23%,
3) upper middle zone = 18.5%,
4) uppermost zone = 20.5%.

In contrast to *A. cepa*, *A. fistulosum* showed crystals in line even in the lowermost zone (Fig. 7).

Many crystals of both the species possess a characteristic marking (Figs 8, 9). Dormer (1961), who found markings of this type in the crystals of *Centaurea*, called it the "central body". In the present study too, where it was found in 48 cultivars of *A. cepa* and in both the varieties of *A. fistulosum*, it was characteristic of a particular zone of the leaf. Here too these markings will be known as the central body. In 96% of the cultivars of *A. cepa* studied,

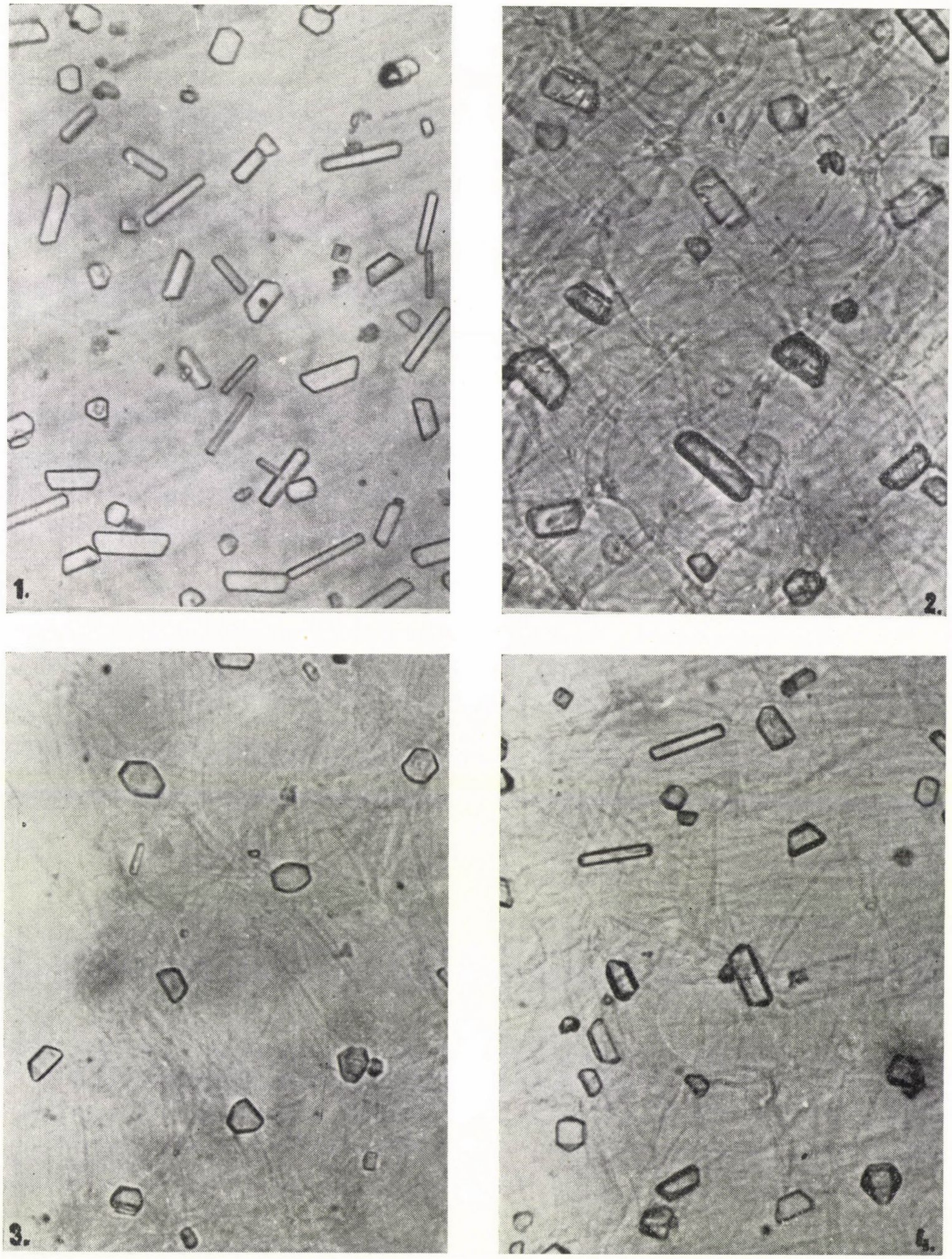


Fig. 3. Frequency distribution of crystals in different zones of *Allium cepa* (1 = lowermost zone, 2 = lower middle zone, 3 = upper middle zone, 4 = uppermost zone)

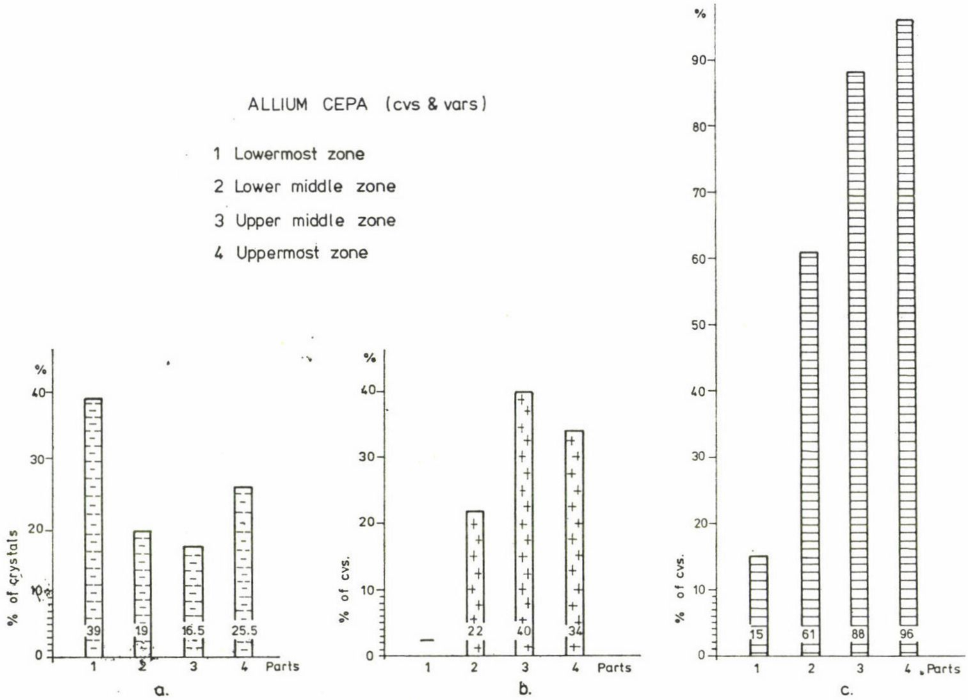


Fig. 4. Characteristic features of *Allium cepa* crystals. *a)* Frequency distribution in the different zones; *b)* Frequency of cultivars with linearly arranged crystals per zone; *c)* Frequency of cultivars having crystals with a "central body"

these markings were present in the uppermost zone, while their occurrence gradually decreases towards the base of the leaf. Their occurrence in the other three zones was as follows (Fig. 4c):

upper middle zone (88% of the cultivars),
lower middle zone (61% of the cultivars),
lowermost zone (15% of the cultivars).

Though all the crystal types described above are present in *A. cepa* to a greater or lesser extent, crystal types A, B, D and E are usually abundant. Crystal type A is much more prevalent in the lowermost zone, while type D is equally abundant in all the different zones Crystal types B and E, though prevalent, are less abundant than types A and D. In *A. fistulosum*, crystal types A, D, E and occasionally B are abundant.

The longest crystals found in *A. cepa* were of types A and D. The length of crystal type A varied from 32.64 μ (cv. Wolska Huser) to 73.1 μ (cv. Makói/(III/49/1975), while those of crystal type D varied from 30.6 μ (cv. Excel Bermuda) to 55.08 μ (cv. Aroma). The breadth of crystal type A varied from 6.12 μ (cv. Excel Bermuda, Wolska Huser) to 11.22 μ (cv. Dichioggia, Filiasi).

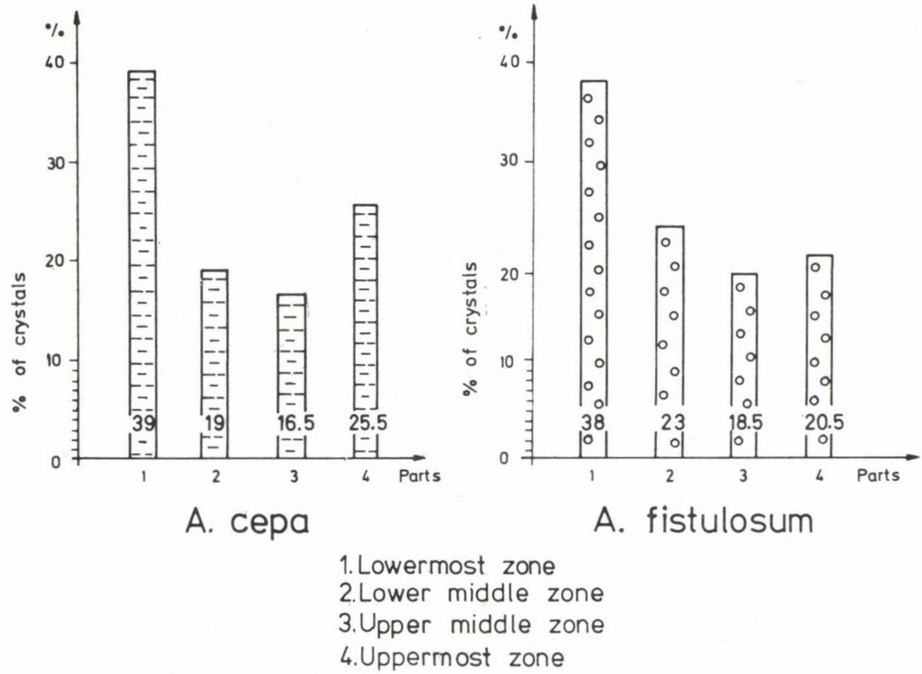


Fig. 5. Frequency distribution of crystals in different zones of *Allium cepa* and *A. fistulosum*

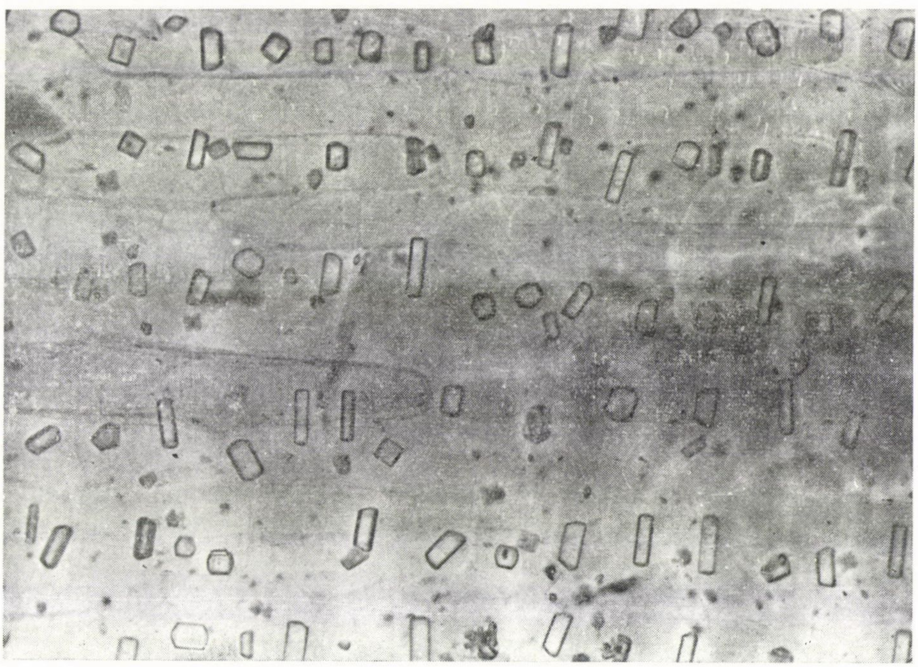


Fig. 6. Linear arrangement of crystals in *Allium cepa* (upper middle zone)

Fig. 7. Linear arrangement of crystals in *Allium fistulosum* (lowermost zone)

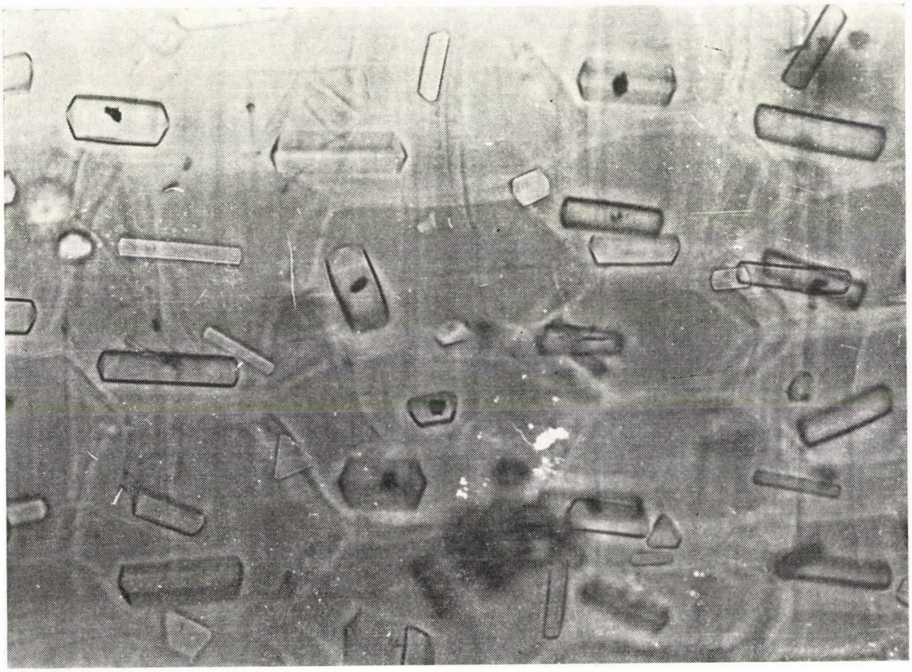


Fig. 8. Allium cepa crystals with a "central body"

Fig. 9. Allium fistulosum crystals with a "central body"

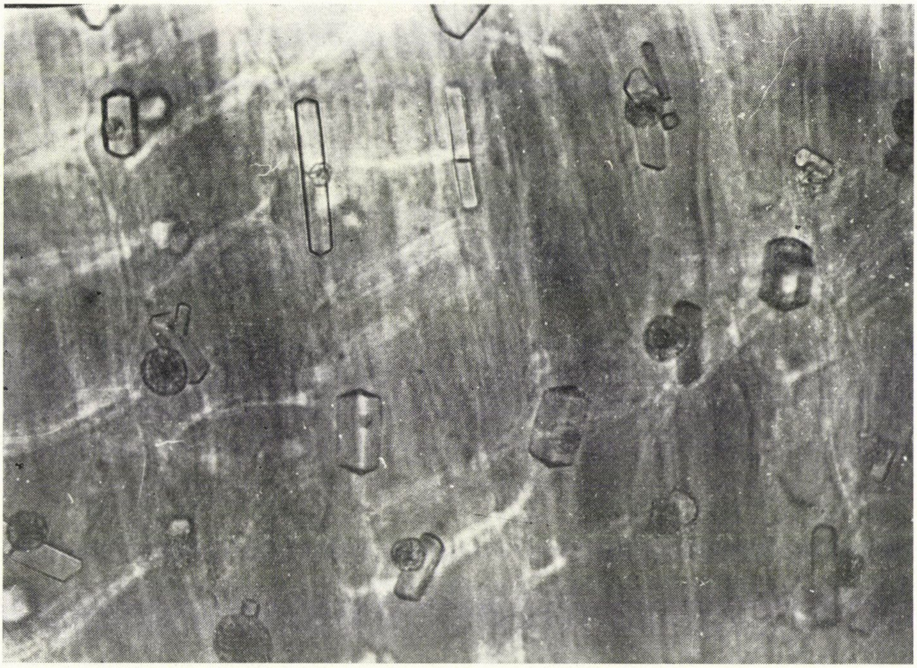


Fig. 10. Sphaerocrystals in the dry scale leaves of *Allium cepa*

The breadth of crystal type D varied from 7.82 μ (cv. Stuart) to 17.34 μ (cv. Makói/III/21/1975).

In *A. fistulosum*, the length of crystal type A varied from 37.06 μ *(A. fistulosum* var. *viviparum)* to 46.24 μ *(A. fistulosum* var. *fistulosum)*; the breadth of this crystal type was 6.12 μ in both the varieties. The length of crystal type D showed only slight variation, being 28.56 μ and 29.92 μ in *A. fistulosum* var. *fistulosum* and *A. fistulosum* var. *viviparum*, respectively. However the breadth varied from 7.14 μ *(A. fistulosum* var. *viviparum)* to 9.18 μ *(A. fistulosum* var. *fistulosum)*.

Discussion

Different types of calcium oxalate crystals were found in the dry scale leaves of *A. cepa* and *A. fistulosum*. Although only a few kinds of crystals have been recorded for these two species in the available literature, other different types of crystals were also found during the present investigation.

The crystals are present in the dry scale leaves of both the species in an orderly manner from the base towards the apex. In *A. cepa* the maximum amount (39%) of crystals was found in the lowermost zone, followed by the uppermost (25.5%), the lower middle (19%) and the upper middle zone (16.5%) (Fig. 4a). But in *A. fistulosum* this sequence was slightly altered, the maximum number of crystals being present in the lowermost zone (38%), followed by the lower middle (23%), the uppermost (20.5%) and the upper middle zone (18.5%) (Fig. 5).

The crystals were found to be arranged in the different zones of the leaves in different patterns. For example, in 40% of the cultivars of *A. cepa* studied, the crystals were in line or in rows in the upper middle zone, followed by the uppermost (34%) and the lower middle zone (22%). In the lowermost zone they were never present in line or in rows but were scattered. But in *A. fistulosum*, the crystals were occasionally found to be in line even in the lowermost zone, but this pattern was more frequent in the lower middle zone.

An interesting characteristic marking was found in many crystals of the materials studied. These markings are known here as the "central body". In *A. cepa*, 96% of the cultivars exhibited these markings in their uppermost zone, followed by the upper middle (88% of the cultivars), lower middle (61% of the cultivars) and the lowermost zone (15% of the cultivars) (Fig. 4c).

Although many different types of crystals were found in the materials examined (Fig. 2), in *A. cepa* crystals of the A, B, D and E types were usually more prevalent. Crystal type A was more prevalent in the lowermost zone, while type D was equally abundant in all the different zones. In *A. fistulosum*, on the other hand, crystals of the A, D and E types, and occasionally type B, were more prevalent.

The longest crystals of all the different types examined were types A and D. Crystal type A was always longer and narrower than type D in any particular leaf. All the different types of crystals in *A. cepa* were longer and broader than those in *A. fistulosum.*

In contrast to reports by JACCARD—FREY (1928), who described a few particular types of crystals to be characteristic of a species of *Allium*, during the present study, different types of crystals were found in all the cultivars of *A. cepa* and also in both varieties of *A. fistulosum.*

The crystals exhibited a systematic distribution in the dry scale leaves of the cultivars and varieties of *A. cepa* and *A. fistulosum.* Moreover, their characteristics were found to be stable and not easily changeable. Though the basic features of the crystals remained the same, they exhibited certain differences at the species level, i.e. between *A. cepa* and *A. fistulosum.* The different cultivars of *A. cepa* showed differences in:

a) the number of crystals present in the different zones of the leaves,
b) the abundant type of crystals present in them,
c) the state of distribution of the crystals, and
d) the occurrence of central bodies.

Accordingly, crystal characters may be used as a taxonomic tool.

References

AL-RAIS, A. H.—MYERS, A.—WATSON, L. (1971): The isolation and properties of oxalate crystals from plants. Ann. Bot., **35,** 1213—1218.

DENFFNER, D. (1971): Morphologie. Lehrbuch der Botanik. VEB. G. Fischer Verlag, Jena.

DORMER, K. J. (1961): The crystals in the ovaries of certain Compositae. Ann. Bot., **25,** 241—254.

DORMER, K. J. (1962): The taxonomic significance of crystal forms in *Centaurea.* New Phytol., **61,** 32—35.

ESAU, K. (1965): Plant anatomy. Second ed. John Wiley and Sons, New York—London—Sydney.

FREY, A. (1929): Calcium-Monohydrat und Trihydrat. In: Linsbauer, K.: Handbuch der Pflanzenanatomie. Verlag G. Borntraeger, Berlin.

FROHNE, D.—JENSEN, M. (1973): Systematik des Pflanzenreichs. G. Fischer Verlag, Stuttgart.

GIBBS, R. D. (1958): Chemical evolution of plants. Journ. Linn. Soc. Lond. (Bot.), **56,** 49—57.

HEGNAUER, R. (1963): Chemotaxonomie der Pflanzen. Birkhäuser Verlag. Basel und Stuttgart, **2,** 274—275.

JACCARD, P.—FREY, A. (1928): Kristallhabitus und Ausbildungsformen des Ca-oxalates als Artmerkmal (Ein Beitrag zur systematischen Anatomie der Gattung *Allium*). Schinz-Festschrift. Beiblatt Nr. 15 zur Vierteljahrsschrift der Naturforschenden Gesellschaft in Zürich, 73.

KÜSTER, E. (1956): Die Pflanzenzelle. VEB Gustav Fischer Verlag, Jena.

RAKOVÁN, J. N.—KOVÁCS, A.—SZUJKÓ-LACZA, J. (1973): Development of idioblast and raphides in the aerial root of *Monstera deliciosa* Liebm. Acta Biol. Hung., **24,** 103—118.

SCOTT, F. M. (1941): Distribution of calcium oxalate crystals in *Ricinus communis* in relation to tissue differentiation and presence of other ergastic substances. Bot. Gaz., **103,** 225—246.

TERPÓ, A.—SARMA, S. I. (1977): Vöröshagyma (*Allium cepa* L.) fajták kalciumoxalát kristályformáinak taxonómiai értéke (Taxonomical significance of the calcium oxalate crystals found in the cultivars of onion [*Allium cepa* L.]). Bot. Közl., **64/3,** 126—132.

Acta Agronomica Academiae Scientiarum Hungaricae, Tomus 29 (1–2), pp. 39–108 (1980)

VARIA

CHARACTERIZATION OF NaCl-EXTRACTED AND PURIFIED MYOSIN

The authors dealt with the purification and characteristics of NaCl-myosin and found that NaCl-myosin can be isolated with a much higher phosphorus content than KCl-myosin. The phosphorus contents of NaCl-myosins show considerable variation, which can be explained by differences in the muscles of the animals (individual variation, perhaps physiological or stress effects). The P content of NaCl-myosin is more sensitive to storage and to changes in the pH or ion milieu than the lower and more stable P content of KCl-myosin. The labile P content of NaCl-myosins isolated with a high P content is hardly increased by the phosphorylation mixture, which suggests that the NaCl-myosins are completely or nearly saturated as regards their labile P content. Inasmuch as this conclusion is correct, it confirms the effect of NaCl with respect to labile phosphate preservation.

The myosin preparation technique is based on the application of an alkaline chloride solution of medium concentration which dissociates the myosin-containing thick filaments and produces a myosin extract. When the extraction time is short the thin filaments and subcellular particles do not dissociate, so they are practically absent from the extract.

Owing to the dissociation of the thick filaments the solution contains monomer myosin molecules, as well as proteins, peptides and non-protein material from the sarcoplasm. In a low ionic strength milieu the myosin forms a flocculent precipitate, thus removing most of the dissolved materials.

Apart from exceptional cases 0.3–0.6 M KCl is usually used to dissociate the thick filaments. EDSALL (1930) claims to have introduced the use of KCl in phosphate buffer following a proposal by HOWE (1924). The reason for this was that within the muscle fibres the K^+ ion had the highest concentration. Indeed, KCl seems to have been used more and more often since then for the extraction of myosin. Since the ionic strength applied earlier was too high (1.3–1.4 μ) and the time of extraction too long, actomyosin and large amounts of accompanying proteins were mainly obtained. The extraction solutions currently used, containing 0.5–0.6 M KCl, and the extraction time, which is optimally short, developed only gradually, and these are now applied with numerous minor modifications.

If habit is a decisive factor in myosin preparation, the other alkali chlorides (Li, Na, Rb and Cs chlorides) could be used on the same grounds as the main component of the extracting solution, since Na^+ ion occurs in the organism in similarly high concentrations and it is a well-known fact that the distribution of the two ions differs considerably. Na^+ ion is usually

The following abbrevations are used below: HC, heavy chain; LC, light chain; DTT, dithiothreitol; EDTA, ethylene diaminotetraacetic acid; EGTA, ethylene glycol-bis-(2-aminoethylether)-N,N'-tetraacetic acid; DTNB, dithio-bis-nitrobenzoate; TRIS, Tris-(hydroxymethyl)-aminomethane; DEAE, diethyl aminoethyl-cellulose.

found intercellularly, while K^+ ion accumulates intracellularly. This selective ion distribution is characteristic of the muscle fibres as well (REISER 1936). Therefore it seems likely that NaCl could be used for myosin preparation just as well, if not better, than KCl.

In early investigations NaCl was widely used, but the concentrations were too high and the ion milieu and pH range were irrealistic. Meanwhile, it has been applied under specific and well defined conditions too, for example by CHEESMAN—WHITEHEAD (1969), and it is sometimes used even now (WEEDS—POPPE 1977), but its use has not been sufficiently justified. Because of the undecided effect of NaCl on myosin extraction, investigations were begun on certain properties of NaCl-myosin.

The experiments were carried out with myosin prepared from the m. long. dorsi of 4—6 month old chinchillas. The extraction and purification of myosin were described in detail in a previous publication (FAZEKAS *et al.* 1979). The only modification which has been made is the substitution of KCl for NaCl in the extraction solution. The composition of the extraction solution is: 0.45 M NaCl, 1 mM $MgCl_2$, 1 mM DTT in 0.1 M sodium phosphate buffer (pH 6.8), and the time of extraction: 10 minutes. The myosin was precipitated with the usual 10—14-fold dilution, the flocculated myosin was collected in a centrifuge, dissolved in 2 M NaCl, then adjusted to the final concentration of 0.5 M NaCl, so that the protein concentration remained at about 25—30 mg/ml. The precipitation was then repeated. The further purification of myosin was carried out on Sepharose 4 B and DEAE-cellulose (DE_{52}) columns, as detailed in the above-mentioned publication.

Inorganic phosphate was applied only in the extraction solution. Solutions containing phosphates were avoided. To maintain the slightly alkaline pH 5—8 mM $NaHCO_3$ was introduced, which kept the pH of the protein solution in the range of 7.6—7.8. The crude myosin was purified by ultracentrifugation (at 105,000 g for 2 hours); some of the lipid accumulated on the surface of the myosin-containing supernatant, whereas some denaturated myosin and any remaining actomyosin sedimented at the bottom of the tubes. The ultracentrifuged myosin was clear and transparent, containing only 2—5% non-myosin proteins.

The P content of the myosin was determined in the inorganic residue decomposed with conc. HNO_3 by the method of FISKE—SUBBAROW (1925), except that the final reduction was arrived at by adding 1% ascorbic acid (1 ml for 10 ml final vol.) according to LOWRY *et al.* (1954). The method is suitable for the determination of 0.05—1.5 μmol P in samples containing 4—15 mg protein.

The RNA content of each myosin preparation was determined with the orcinol method of SCHNEIDER (1957), and the remaining nucleotide content by the method of ASAKURA (1961). The $HClO_4$ concentration of the samples was adjusted to 5%, and UV absorption was measured in the supernatants at 259 nm. When, because of the presence of some contamination, the nucleotide spectrum was not characteristic and the concentration could not be correctly calculated from absorption, the samples were applied to a DOWEX 1×8 (0.5×6 cm) column and the total nucleotide concentration was determined from the eluated fractions.

The lipid content was checked in each preparation. The samples were extracted twice with a mixture of chloroform-methanol (2 : 1) and once with acetone containing 4—6% distilled water. The dry weight contents of the extracts were obtained at 105°C and measured gravimetrically. After decomposition with conc. HNO_3 the inorganic P content was determined. Finally the P content was also determined in the lipid-free myosins.

The Ca^{2+}-dependent ATP-ase activity was determined in 2 ml final volume for 0.2—0.9 mg myosin, *a)* at low ionic strength in the presence of 30 mM NaCl, 10 mM $CaCl_2$, 25 mM TRIS-HCl (pH 7.4), and 1 mM ATP, and *b)* at high ionic strength in the presence of 0.5 M NaCl. Incubation was started at 30°C after 5 minutes of preincubation by adding ATP and stopped with 2 ml of 15% TCA after 3 or 5 minutes of incubation. The hydrolysis of ATP was determined by an assay of the released inorganic phosphate in 2 ml of filtrates. In order to compare the activity a double control was applied: ATP was omitted from one, and myosin from the other incubation mixture.

The actin-activated myosin ATP-ase was determined in 2 ml final volume in the presence of 0.4—1.0 mg myosin, 6 mM NaCl, 1.5 mM $MgCl_2$, 25 mM TRIS-HCl (pH 7.8), 1 mM ATP, and varying concentrations of actin (1—4 mol per mol myosin). Incubation was started with ATP, and the inorganic P gained from hydrolysis was determined in the protein-free supernatant. The activity was defined for ATP hydrolysis in μmol Pi · protein mg^{-1} · · min^{-1}.

The phosphorylation ability of myosin was determined in a two-stage incubation system containing 100—120 mg myosin. Each incubation mixture contained 4 ml (100—120 mg) myosin, 6 mM $MgCl_2$, 25 mM KCl, 2 mM $KHCO_3$, 1.5 mM $NaHCO_3$, 20 mM TRIS-HCl (pH 7.6), $2-5\times10^5$ M $CaCl_2$ and 1.25 mM ATP. First the solution containing myosin and the TRIS-HCl buffer were introduced into the incubation tube, then the other components in the form of two solutions. Solution I was Mg-ATP: 80 mM $MgCl_2$, 10 mM ATP and 1 mM DTT; solution II was a salt solution containing 100 mM KCl, 0.2 mM $CaCl_2$ and 5 mM $NaHCO_3$.

Myosin phosphorylation was started by introducing a calculated amount of solutions I and II into the tubes of preincubated myosin. This was done quickly and successively, because the phosphorylation of myosin was found to be a quick reaction. The phosphorylation was terminated, after 30 or 60 seconds of incubation, by adding 5 vol. of icy distilled water. The formation of myosin flakes started at once; they were collected by centrifuging at 5000 g for 5 minutes. The remaining nucleotides and inorganic phosphate were removed with the washing solution (10 mM KCl, 20 mM NaCl, 1 mM $MgCl_2$, 1×10^{-5} $CaCl_2$ and 8 mM $NaHCO_3$). The precipitate was first suspended in a small amount of washing solution, then diluted to a 10—15-fold volume, and recollected by centrifuging. Washing was repeated several times using the same method. After the fourth washing the phosphate and nucleotide contents were determined in the dried myosin residue (obtained at 105°C).

When the phosphorylated myosin was dissociated and separated into light and heavy chains a larger quantity (at least 500—800 mg) of myosin was phosphorylated. The phosphate content was determined in the mixed LC and separated LC subunits as well as in the HC fractions, and the values given refer to the dry weight of 478,000 g myosin.

The absorption spectrum of NaCl-myosin is similar to that of KCl-myosin. The concentration of ultracentrifuged myosin can be estimated by UV absorption in the same way as for KCl-myosin. The extinction value for 1 mg/ml myosin concentration at 280 nm is 0.570 when the irrelevant absorption measured at 320 nm, which is usually insignificant, is subtracted. The protein concentration was measured by the microbiuret method (Goa 1963), calculated on the basis of the protein nitrogen content of the dry matter by Kjeldahl's method and checked by determining the salt and lipid contents. The molar extinction of myosin calculated in this way was $\varepsilon = 2.625\times10^5$ litre · mol^{-1} · cm^{-1} for 478,000 g, the same as that obtained for KCl-myosin.

The calculation of the protein concentration in gel-filtrated myosin solutions does not require any correction. The ultracentrifuged myosin contains 0.05—0.1% RNA and 2—6% other non-myosin proteins.

On preparing lipid-free myosins 0.5—0.9% dry residues are found in the organic extract, of which 1.9—2.3 mol proved to be phospholipids according to the P determination.

The specific activity of Ca-activated NaCl-myosin ATP-ase is 0.202 μmol Pi · min^{-1} · · mg^{-1} in the presence of 0.5 M NaCl and 50 mM TRIS-HCl buffer (pH 7.6), and 0.38 μmol Pi in the presence of 30 mM NaCl, while the actin-activated myosin ATP-ase specific activity is 0.523 μmol · min^{-1} · mg^{-1} with a myosin : actin ratio of 1 : 4.

Numerous properties of NaCl-myosin do not differ from those of KCl-myosin. No distinct differences were found when examining superprecipitation, solubility and the formation of precipitates. But for one property, the phosphorus content, the difference is remarkable. The P content in every one of the NaCl preparations was higher than that of KCl-myosin. Since the higher P contents of earlier NaCl-myosin preparations (15—22 moles P/mole of myosin) could not be evaluated owing to the wide variation, an attempt was made to follow the P contents in each phase of purification (except extract I). In one or two cases the P contents of myosins were determined in the dorsal muscles of other breeds of rabbit or hare and the results were compared. Our findings are summarised Table 1.

Table 1

"Preparative P content" in ultracentrifuged myosin

No.	Mole P/mole of myosin (for 478,000 g)
214	32.53 (26.5—34.0)+
215	22.3 (19.3—24.1)
216	15.3 (14.1—16.4)
217	24.6 (20.5—25.8)*
218	19.53 (18.2—21.5)**
234	13.2 (11.6—15.4)**
232	7.65 (7.1— 8.5)***
227 (control, KCl-myosin)	11.9 (11.4—12.7)

+ Hare myosin
* This myosin was prepared from the back muscles of three rabbits from the same litter.
** NaCl-myosin and
*** KCl-myosin from the back muscle of a "Vienna blue" rabbit.

The dorsal muscle of chinchilla contains 76—90 μmole P/g of fresh muscle which gradually decreases to an average of 25 μmol P/g, i.e. to the preparative P content shown in mol/mol values in the table. Gel filtration in a medium containing 0.5 M NaCl, 8 mM $KHCO_3$, 1 mM $MgCl_2$ and $2 \cdot 10^5$ M $CaCl_2$ hardly reduces the preparative P content at all. It was concluded from the results that NaCl promotes the preservation of labile phosphate in the myosin, with the result that fluctuations in the P content of myosin preparations from various animals become more conspicuous.

In our experiments a good deal of information is available to show that the presence of KCl is required for the phosphorylation of NaCl-myosin. So the composition of the phosphorylation mixture is the reverse of that required for KCl-myosin. However, it was surprising that the P content of myosins with a high P content is hardly increased by phosphorylation. The omission of KCl or the substitution of KCl for NaCl, in either the myosin solution or the incubation mixtures, results a reduction in the P content. Since the P content is determined from the dry residues of washed myosin samples, the question arises whether the reduced amount of P is due to the absence of phosphorylation or to the effect of the washing solution. Table 2 offers a few examples of this.

The data and other observations equally suggest that neither the phosphorylation nor the washing solution are ideal. It has only proved possible to phosphorylate myosins with lower P contents, while higher P contents have always decreased. Further investigations are being made in order to find the optimum conditions.

In the course of our investigations an interesting problem has been cleared up. SZENT-GYÖRGYI's (1943) expermients showed the dependence of myosin solubility on ion concentration and pH. With NaCl and KCl concentrations in the range 50—1.5 mM the myosin precipitates, but at lower concentrations it redissolves. On repeating the experiments with gel-filtrated myosin we found that not only the myosin dialysed from KCl* and NaCl* but also that dialysed against 0.4 mM $KHCO_3$ became dissolved, but the P content of the myosins decreased to 4.45, 4.3 and 4.7 mol, respectively, with the simultaneous dissociation of a large quantity of LC.

If dialysis is carried out against a simple buffer-free solution of 0.4 mM NaCl or KCl, as in Szent-Györgyi's original experiment, the P content is reduced to 1.98 mol (on average) because of a decrease in the pH of the dialysate to 5.3—6.0. If the dialysing solution of NaCl or KCl contains a small quantity (100 μmol/litre) of $KHCO_3$ or $NaHCO_3$, a larger amount of P, in most cases 7.9 mol P/mol of myosin, will be preserved. Similar results were obtained in a reverse ratio when a small quantity (40—100 μmol/litre) of NaCl or KCl was present in a solution of $NaHCO_3$ or $KHCO_3$. The results suggest that the preservation of labile P in myosin requires Cl^- ion.

When NaCl-myosin is dissociated to HC and LC subunits and freed from lipids, the P content of the HC fraction decreases to 4—5 mol and that of the LC fraction to 1.85 mol (without separation and averaged for 20,000 mol wt).

Table 2

Effect of distilled water, washing solution and phosphorylation mixtures on the P content of NaCl-myosin (mole P/mole of myosin)

No.	Control*	Phosphorylated myosin		Washed with dist. water, control*** (pH 5.9—6.3)
		with total phosph. mix.**	without KCl**	
214	32.53	21,1	30.5	8.1+
215	22.1	20.2	—	1.98
216	15.3	20.7	16.6	6.1
217	24.6	23.5	18.0	7.5
218	19.53	—	—	4.1
234	13.2****	16.2	12.5	2.65

+ Hare myosin has the highest P content, being much higher than that of chinchilla myosin. The phosphorylation and P content for KCl- and NaCl-myosin from hare muscle will be detailed elsewhere.

* Determined in fresh preparation immediately after purification.

** Nucleotide contents were found to be 0.07—0.4 M in perchloric acid supernatants.

*** ATP and buffer were omitted from the incubation mixture and the myosin was washed only with distilled water five times successively.

**** Vienna blue rabbit.

The various LC fractions separated on a DEAE-cellulose column, show varying amounts of P. The DTNB chain, in particular, shows varying quantities of phosphates. By gradual elution 3 phosphorylated forms are obtained. The highest P content in the last fraction may be as high as 5 mol. In many cases increased P contents are also found in the A_2

* The dialysing solution contains 0.4 mM KCl or NaCl and 100 μmol/litre TRIS-HCl buffer (pH 7.2).

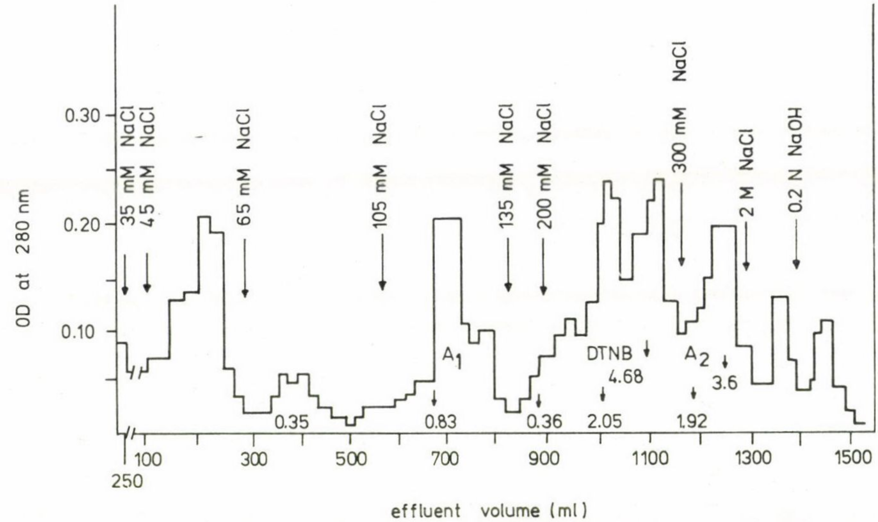


Fig. 1. Separation of mixed light chain fractions of phosphorylated NaCl-myosin by gradient elution on a DEAE-cellulose column (2.3×30 cm). Dissociation to heavy and light chains was achieved by adding 1 mM DTT, 1 mM $MgCl_2$, 1×10^{-5} M $CaCl_2$ and NH_4Cl up to a concentration of 4.7 M, using an electromagnetic stirrer. The LC fraction was dialysed exhaustively five times with a solution of 0.1 mM DTT, 35 mM NaCl, 5 mM KCl, 5 mM $NaHCO_3$, 1 mM $MgCl_2$ and 1×10^{-5} M $CaCl_2$ and applied to the column. The column was washed before elution with 250 ml each of 35 mM and 45 mM NaCl, and eluated by growing concentrations of NaCl solution, as shown in the figure. Besides the concentration indicated, each elution mixture contained 9 mM $KHCO_3$ and 0.1 mM DTT. The elution of the individual LC fractions was followed by UV light at 280 nm. The P content was traced for each fraction by taking 0.1 ml aliquots and determining the content with the ammonium molybdate method after reducing the final volume to 2 ml. The nucleotide was checked in a pooled and dialysed fraction with a 280/260 ratio of extinction. The P contents are marked with Arabic numerals

subunit. Further, the more the myosin was washed the lower the amount of A_2 was found to be. This may mean that the A_2 subunit is less closely associated in the myosin than the A_1. In the majority of preparations the P content of other subunits was also lower when they derived from myosins containing A_2 in reduced quantities.

In Fig. 1 the P contents found in the LC fractions of one of the preparations are indicated by Arabic numerals.

In our previous investigations the preparative P content of KCl-myosin was found to average 12 mol (Fazekas *et al.* 1978), increasing by 5–9 mol under the influence of the phosphorylation. These results are confirmed and augmented by our present investigations.

The preparative P content of NaCl-myosin is higher than that of KCl-myosin. The higher P content of NaCl-myosin varies from preparation to preparation as most of it is labile phosphate. It is possible that the wide fluctuation is due to more than one cause. It may indicate individual variation, the accumulation of minor preparative errors caused by the ion- and pH-sensitiveness of the labile P content, or the effect of perceptible stresses and tetanic twitches observed in animals during exsanguination. Irrespective of the cause, the "higher preparative P content" of NaCl-myosin does exist, as does the difference perceived between myosins isolated with lower and higher P contents, whereby the former can be phosphorylated while the latter cannot. The question arises whether myosins obtained with a higher P content might indicate a certain saturation for labile phosphates, while the lower P content myosins represent a phosphate deficiency. The above questions call for further data collection in order to be able to clear up many details.

It seems that the variation of the P content in NaCl-myosin cannot be explained by concomitant protein, as the quantity of the latter is not larger than in KCl-myosin, in fact it is smaller, if anything.

Myosin and actomyosin are the only proteins known so far which bind Na^+, K^+, and H^+, this has not been observed with other proteins. The preservation of the labile P of myosin is presumably connected with the effect of the Na^+ ion and can be explained on the basis of the experiments of LEWIS—SAROFF (1957), who found all three ions to be bound to the residues of histidines in myosin.

The binding of ions is pH dependent. One of the two metal ions, the K^+ ion, shows an inflection point at pH 6.5. Myosin has a much greater capacity for Na^+ than for K^+ ion and at pH 7.7 nearly six times as many Na^+ ions as K^+ ions are bound. On this basis the binding of labile P seems to run parallel to the linkage of Na^+ ions in myosin.

All the subunits of NaCl-myosin, including the HC and LC subunits, contain phosphate. As the phosphate remains bound to the subunits under the conditions of preparation, this suggests a covalent linkage rather than the formation of chelates including metal ions. The chromatogram in Fig. 1 shows the separation and P contents of the LC subunits of a myosin with an average P content (18 mol per mol). In high P-content (20—32 mol per mol) myosins the P content of the HC may reach 8—9, and that of the LC subunits 2, 2—5 and 4—5 mol P content (for A_1, DTNB and A_2, respectively).

The motion of the labile phosphates of myosin is well perceptible within the subunits. It has been found that migration tends to release the P or to form ester phosphates in the subunits. The "migration" stops with the dissociation of myosin; at the same time the release of P is continued at a lower rate in the subunits.

In our experience the use of DTNB, EDTA and EGTA should be avoided during the dissociation of myosin, because the chelate forming substances and the DTNB cause a reduction in the subunits and in their P contents KASMAN—KAKOL (1977) made similar observations.

The Na^+ ion dependent phosphorylation is also well known in other systems displaying ATP-ase activities, such as in Na^+, K^+-ATPase (SOMOGYI *et al.* 1976), kidney Na^+, K^+-ATP-ase (KANIIKE *et al.* 1976), and muscle membranes (REDDY *et al.* 1976). The protective effect of Na^+ ion on P burst is also known (LOWE—SMART 1977). However, when this effect of NaCl is compared to the NaCl-myosin — labile P system it seems to be not a homologous, but only an analogous phenomenon.

Summarizing, our earlier and present investigations confirm the experimental results achieved by CHEESMAN—WHITEHEAD (1969), DAVIES (1971), and the still earlier findings of KANAZAWA—TONOMURA (1965), to the effect that the amount of labile phosphate varies in muscles (at least in m. long. dorsi studies) showing an increase during relaxation and a decrease during contraction. Further, the present results agree with the results of STRACHER (1965) who found the participation of 8 histidines to be important in the catalytic activity of myosin. The only difference is that the latter author considered the histidines to be important in the hydrolysis of ATP, while the present authors feel that the role of histidine is in the phosphorylation of myosin, in other words in maintaining the active state of the muscle.

Acknowledgements

The authors are grateful to Prof. Antoni for his deep interest and valuable advice, and thank Mrs. Bökönyi for her skilful technical assistance.

*

Prepared at the 2nd Institute of Biochemistry and Psychiatric Clinic, Semmelweis Medical University; Department for Applied Chemistry of the Technical University, Budapest.

S. Fazekas, V. Székessy-Hermann, I. Óváry, I. Kása

References

Asakura, S. (1961): The interaction between G-actin and ATP. Arch. Biochem. Biophys., **92**, 140–149.

Cheesman, D. F.—Whitehead, D. A. (1969): Possible role in contraction of structurally bound phosphate of muscles. Nature, **221**, 736–739.

Davies, R. E. (1971): Energy-rich phosphagenes. Adv. in Exp. Med. and Biol., **11**, 327–329. (Ed. by Bengt Pernoy and Bengt Saltin, Plenum Press, New York and London.)

Edsall, J. T. (1930): Studies in the physical chemistry of muscle globulin (myosin). J. Biol. Chem., **89**, 289–313.

Fazekas, S.—Székessy-Hermann, V.—Óváry, I. (1979): Decrease and autophosphorylation increase of the labile phosphate content in myosin. Acta Agron. Acad. Sci. Hung., **28**, 301–312.

Fiske, H. C.—Subbarow, Y. (1925): The colorimetric determination of phosphorus. J. Biol. Chem., **66**, 375–400.

Goa, J. (1963): A microbiuret method for protein determination of total protein in cerebral fluids. J. Clin. Lab. Invest., **2**, 218–223.

Howe, P. E. (1924): The differential extraction and precipitation of the soluble proteins in the muscle of cow, calf and rabbit. J. Biol. Chem., **64**, 493–522.

Kanazawa, T.—Tonomura, Y. (1965): Pre-steady state of myosin adenosine triphosphatase system. Initial rapid liberation of inorganic phosphate. J. Biochem. Tokyo, **57**, 604–611.

Kaniike, K.—Lindermayer, G. F.—Wallicke, E. T.—Lane, L. K.—Schwartz, A. (1976): Specific sodium-22 binding to a purified sodium + potassium adenosine triphosphatase. J. Biol. Chem., **251**, 4794–4795.

Kasman, K.—Kakol, I. (1977): The influence of the ethylene diaminotetra-acetate on white skeletal muscle myosin. Biochim. Biophys. Acta, **491**, 509–514.

Lewis, M. S.—Saroff, H. A. (1957): The binding of ions to the muscle proteins. Measurement on the binding of potassium and sodium ions to myosin A, myosin B, and actin. J. Am. Chem. Soc., **79**, 2112–2117.

Lowe, A. G.—Smart, J. W. (1977): The pre-steady state hydrolysis of ATP by porcine brain ($Na^+ + K^+$)-dependent ATP-ase. Biochim. Biophys. Acta, **481**, 695–705.

Lowry, O. H.—Robert, M. R.—Leiner, K. Y.—Wu, M. L.—Farr, A. L. (1954): The quantitative histochemistry of brain. I. Chemical methods. J. Biol. Chem., **207**, 1–15.

Reddy, N. B.—Kingengel, W.—Festoff, W. B. (1976): In vitro studies on skeletal muscle membranes. Characterisation of a phosphorylated intermediate of sarcolemmal (Na^+, K^+) ATP-ase. Biochim. Biophys. Acta, **433**, 365–382.

Reiser, O. (1938): Vergleichende Muskelphysiologie. Ergeb. Physiol., **38**, 134–250.

Schneider, W. C. (1957): Determination of nucleic acid in tissue by pentose analysis. In: Colowick, S. P.—Kaplan, N. O. "Methods in Enzymology". III. 680–684.

Somogyi, J.—Schön, R.—Vodnyánszky, L.—Varga, V.—Hatfaludi, F. (1976): $Na^+ + K^+$-aktiválható adenozintrifoszfatáz mint az energiaátalakítás modellje ($Na^+ + K^+$-activated adenosine-triphosphatase as a model of energy transformation). MTA Biol. Közl., **19**, 395–407.

Stracher, A. (1965): Evidence for histidine at active site of myosin A. J. Biol. Chem., **240**, PC 958.

Szent-Györgyi, A. (1943): The crystallization of myosin and some of its properties and reactions. In "Studies from Inst. of Med. Chem. Univ." Szeged., Vol. III. Karger, S., Basel—New York, 76–85.

Weeds, A. G.—Poppe, B. (1977): Studies on chymotryptic digestion of myosin. Effect of divalent cations on proteolytic susceptibility. J. Mol. Biol., **111**, 129–157.

PEAK LEVELS OF ENDOGENOUS CYTOKININS AFTER DECAPITATION IN LEAVES OF LEGUMINOUS PLANTS: INCREASE OF PROTEIN AND CHLOROPHYLL CONTENTS AND PHOTOSYNTHETIC $^{14}CO_2$ FIXATION

The stimulative effect of synthetic cytokinin (kinetin) on the growth of plants was described by SCOTT—LIVERMAN (1956) and again by KURAISHI—OKUMURA (1956). It was almost a decade later that an endogenous "root factor" produced in the roots was demonstrated by SETH—WAREING (1965) and BURNETT *et al.* (1965) to have an intensive stimulation on the growth of leaves (surface extension, dry matter accumulation); but no evidence of endogenous purine-type, cytokinin-like biological activity levels having a direct influence on the growth and nitrogen metabolism of the leaves or on the intensity of carbon dioxide fixation related to the chlorophyll content has so far been produced.

SKOOG *et al.* (1965) defined the cytokinin effects as the biological activity accompanying the increase in the frequency of mitosis, which stimulates the growth of tobacco callus; they thus left many highly important side-effects of synthetic and endogenous cytokinin treatments out of consideration. On examining the side-effects of synthetic cytokinins and endogenous cytokinin-like biological activities, a substantial stimulation of the chlorophyll level and of the intensity of photosynthetic carbon dioxide fixation could be demonstrated in addition to an increase in the protein nitrogen content (POZSÁR 1967, 1971, 1972, 1974, HORVÁTH—POZSÁR 1974). It is particularly important to emphasize that the primary effect of the cytokinin treatment is to increase the absolute and relative quantities of the soluble protein fraction (POZSÁR 1971, 1972).

The present paper gives experimentally based answers to the questions of what the conditions are under which the highest level of endogenous cytokinin-like biological activity can be demonstrated in the leaves of plants, to what extent this extra high level increases the nitrogen content and the amount of protein nitrogen in the leaves, how it influences the C : N ratio, and what correlation it ensures between the increase in the chlorophyll level and the intensity of photosynthetic carbon dioxide fixation. These questions are all the more justified because the biological activity displayed in the increased intensity of protein synthesis and photosynthetic carbon dioxide fixation is the most important of all the side-effects accompanying the synthetic and endogenous cytokinin effects.

The separation of endogenous cytokinin-like biological activities was carried out using the procedure described by van ONCKELEN *et al.* (1965); the purity of the isolates corresponded to about 90% benzyladenine and consisted almost entirely of purine-type compounds. The endogenous cytokinin-like biological activities were related to benzyladenine effectivity (SZABÓ *et al.* 1970). The bioactivity was tested by the incorporation of glycine-2-^{14}C into protein and was expressed in mg benzyladenine (SZARVAS—POZSÁR 1977). The total and protein nitrogen contents were determined by the micro-Kjeldahl method and were expressed as a percentage of the dry matter. The organogenic elements were examined by gas analysis and, although the C, O, H and N contents were expressed, only the C : N ratio was documented. The chlorophyll content was expressed in extinction, on the basis of repeated methyl alcohol extraction. The intensity of photosynthetic carbon dioxide fixation was studied by the method described earlier, and the values of light and dark fixation obtained by liquid scintillation were expressed in absolute beta-activity, the arithmetic difference of which is the photosynthetic carbon dioxide fixation.

On the basis of the data in Table 1 it was directly proved that as a response to decapitation the organic matter levels examined increased almost equally favourably in the leaves of bean and alfalfa plants. It should be noted that the lower values were consistently found in the bean leaves and the higher ones in the alfalfa leaves. As a consequence of decapitation the endogenous cytokinin-like biological activity levels rose seven- and eight-fold by the end of

Table 1

Cytokinin-like biological activity determined after two weeks in the leaves of intact and decapitated plants, in 10 g dry matter, related to mg benzyladenine, with the effects of the isolated purine-type compounds tested by the incorporation of glycine-2-^{14}C into protein. In the primary leaves (bean) and first trifolium (alfalfa) of treated and untreated plants the data obtained by the micro-Kjeldahl method for total and protein nitrogen refer to dry matter; the latter samples were crushed after precipitation with 10% trichloracetic acid at +4°C. The C : N ratio is a quotient calculated from the data of C and N contents obtained by gas analysis. The chlorophyll content refers to 200 mg fresh leaves after methyl alcohol extraction up to discoloration, expressed in extinction measured at 760 mμ. The intensity of photosynthetic carbon dioxide fixation is the difference between 15 minutes of light and dark fixation referred to 100 mg fresh weight, in 200 μCi/li gas space, expressed in mμCi data

Levels, ratios	Test units	Bean				Alfalfa			
		Intact		Decapit.		Intact		Decapit.	
		Mean	Deviation	Mean	Deviation	Mean	Deviation	Mean	Deviation
End. cyt.	mg BA	54.0	6.1	430.0	35.0	46.0	3.9	387.0	25.4
Total N	N %	2.9	0.5	3.7	0.6	3.8	0.6	5.0	0.7
Protein N	N %	1.7	0.4	2.8	0.5	2.4	0.4	4.2	0.5
C : N	Q	1.65	—	1.20	—	1.47	—	1.02	—
Chlorophyll	ext.	1.514	0.124	2.038	0.163	2.670	0.195	3.844	0.280
Photosyn. CO_2	mμCi	1.82	0.13	3.57	0.26	2.15	0.18	4.33	0.30

the second week following the decapitation. The levels have to be regarded as exceptionally high, as similarly high values have not been published so far for endogenous levels. The respective peaks show the potentials of the leaves of legumes, in connection with the exceedingly high nitrogen levels. The total nitrogen content increased by 27 and 31%, respectively, suggesting that under the influence of a remarkable "root factor" accumulation in the leaves the nitrogen uptake in the roots and the nitrogen accumulation in the examined leaves increased. The increase in protein nitrogen content was much more remarkable (64 and 79%); this can be explained by the rising intensity of protein synthesis. The relevant data prove, furthermore, that alongside the significant increase in protein synthesis, protein decomposition does not take place in the intensified nitrogen metabolism. Again, it should be emphasized that the rise in the protein nitrogen level is not in proportion with the increase in the endogenous cytokinin-like biological activity levels of the leaves, which is almost of an order of magnitude. The C : N ratio decreased by 28 and 31%, respectively; this can be regarded as the consequence of the nitrogen uptake and similarly shows the potential of legume leaves. The chlorophyll content increased by 34 and 44%, respectively, as related to fresh weight, and the photosynthetic carbon dioxide fixation increased by 96 and 101%, respectively. These data show that the photochemical activity of the chlorophyll increased to a much greater extent than the chlorophyll content did compared to the intensity of photosynthetic carbon dioxide fixation. The intensity of photosynthetic carbon dioxide fixation did not increase proportionately to the endogenous cytokinin-like biological activity but lagged behind it considerably as did the increase in the protein content.

On the basis of the experimental data a direct and positive correlation can be demonstrated under special conditions between the increase in endogenous cytokinin-like biological activity levels, the increase in the nitrogen metabolism and the rise in the intensity of photosynthetic carbon dioxide fixation in the leaves of leguminous plants. The increases in the nitrogen level, the protein nitrogen content, the chlorophyll level and the intensity of photosynthetic carbon dioxide fixation are just a small part of the extremely high increase demonstrated in the endogenous cytokinin-like biological activity.

It is assumed that decapitation does not enhance the synthesis of endogenous cytokinin-like biological activity in the roots, but in the absence of actually growing tissues the remaining leaves continue to grow, since it is in these that the endogenous cytokinin-like biological activity transported from the roots accumulates. The endogenous cytokinin-like biological activity is realized primarily in mitotic activity and secondarily expressed in organic matter accumulation. A minor, but not insignificant part of the endogenous cytokinin-like biological activity is incorporated in the cell structure at the polyribosomic level, according to the experimental data of Key (1969), Bhattacharyya—Roy (1969), Klämbt (1974, 1976), Maass—Klämbt (1977), Gordon *et al.* (1975) and Fox—Erion (1975). According to these results the endogenous cytokinin-like biological activity directly enhances protein synthesis while relatively reducing the non protein nitrogen level (NPN); the relevant correlation was proved in an earlier paper (Szarvas—Pozsár 1977).

An important side-effect of the endogenous cytokinin-like biological activity, which was demonstrated earlier, is the stimulation of the intensity of photosynthetic carbon dioxide fixation, indirectly through an increase in the soluble protein level (Pozsár 1967) and directly through the bioactivity of the imido nitrogen (Horváth—Pozsár 1974). The biological activity of the imido nitrogen can be explained by its proton transferring activity (Szabó—Pozsár 1974); our earlier paper can be supplemented by pointing out that by means of the proton transport of the imido nitrogen the ATP level substantially increases through the activity of the dehydrogenases. In the course of this latter bioenergetic process the phosphorylation of sugars becomes more intensive, whereby the carbon cycle is stimulated; this is how the observed double stimulation of the photosynthetic carbon dioxide fixation can be interpreted.

*

Prepared at the Institute of Isotopes of the Hungarian Academy of Sciences, Organic Chemistry Department, Budapest.

B. I. Pozsár

References

Bhattacharyya, J.—Roy, S. C. (1969): Growth promotors and the synthesis of protein in plant mitochondria. I. Effect of kinetin on the incorporation of amino acids into mitochondrial protein. Biochem. Biophys. Res. Commun., **35**, 606—610.

Burnett, D.—Audus, L. J.—Zinsweiter, A. (1965): Growth substances in the roots of Vicia faba. II. Phytochemistry, **4**, 891—901.

Fox, J. E.—Erion, J. L. (1975): A cytokinin protein from higher plant ribosomes. Biochem. Biophys. Res. Commun., **64**, 694—700.

Gordon, M. E.—Letham, D. S.—Beever, J. E. (1975): Regulators of cell division in plant tissues. XXIV. The effect of cytokinins on ribosome yield from radish cotyledons. Physiol. Plantarum, **35**, 27—33.

Horváth, L.—Pozsár, B. I. (1974): Effect of benzimidazole and its derivatives on the intensity of photosynthetic carbon dioxide fixation in alfalfa and maize leaves. Acta Agron. Hung., **23**, 355—358.

Key, J. L. (1969): Hormones and nucleic acid metabolism. Ann. Rev. Plant Physiol., **20**, 449—474.

Klämbt, D. (1974): Einfluss von Auxin und Cytokinin auf die RNS-Synthese in sterilem Tabakgewebe. Planta, **118**, 7—16.

Klämbt, D. (1976): Cytokinin effects on protein synthesis of in vitro systems of higher plants. Plant a. Cell Physiol., **17**, 73—76.

Kuraishi, S.—Okumura, F. Sh. (1956): The effect of kinetin on leaf growth. Bot. Mag., **69**, 817—818.

MAASS, H.—KLÄMBT, D. (1977): Cytokinin effect on protein synthesis in vivo in higher plants. Planta, **133,** 117—120.
POZSÁR, B. I. (1967): A szintetikus citokininek hatása a klorofill fotokémiai aktivitásának fokozódására, bablevelekben (Effect of synthetic cytokinins on the increase in the photochemical activity of chlorophyll in bean leaves). Bot. Közlem., **54,** 219—225.
POZSÁR, B. I. (1971): The determination of the effect of soluble protein level on the intensity of photosynthetic carbon dioxide fixation. Acta Agron. Hung., **20,** 197—203.
POZSÁR, B. I. (1972): DNS, RNS és fehérje szintézis vizsgálatok Pinto babfajta levélszövetében, potenciális purin és pirimidin bázisanalógok segítségével (Analyses of DNA, RNA and protein syntheses in the leaf tissue of Pinto bean by means of potential purine and pyrimidine base analogues). Növénytermelés, **21,** 291—298.
POZSÁR, B. I. (1974): Physiology of host-pathogen interrelation with respect to protein levels. Acta Agron. Hung., **23,** 119—122.
SCOTT, R. A.—LIVERMAN, L. (1956): Promotion of leaf expansion by kinetin and benzylaminopurine. Plant Physiol., **31,** 321—322.
SETH, A.—WAREING, P. F. (1965): Isolation of kinin-like root-factor in Phaseolus vulgaris. Life Sci., **4,** 2275—2280.
SKOOG, F.—STRONG, F. M.—MILLER, C. O. (1965): Cytokinins. Science, **148,** 532—533.
SZABÓ, L. GY.—POZSÁR, B. I. (1974): Az imido-nitrogén effektivitása néhány biológiailag aktív heterociklusos vegyületben (Effectivity of imido nitrogen in some bioactive heterocyclic compounds). Növénytermelés, **23,** 173—177.
SZABÓ, L. GY.—POZSÁR, B. I.—V. KOTA, M. (1970): Cytokinin activity of the fruiting body of Coprinus micaceus Ff. Acta Agron. Hung., **19,** 402—403.
SZARVAS, T.—POZSÁR, B. I. (1977): Az NPN arányok és az endogén citokinin szintek közötti negatív összefüggés micéliumokban és levelekben (Negative correlation between NPN ratios and endogenous cytokinin levels in mycelia and leaves). M. Mikrobiol. Társ. Mg. és Ipari Mikrobiol. Szekció, Sopron 1977. 1—7.
VAN ONCKELEN, H. A.—VERBEEK, R.—MASSART, L. (1965): Detection of a kinetin-like factor in barley with a new bioassay on kinetin-like activity. Naturwissenschaften, **52,** 46—47.

CHANGES IN THE YIELD STRUCTURE OF MAIZE

The yield structure of maize is analysed with the method described earlier (ERDŐS 1976, 1978). The yield can be regarded as the result of the joint action of three basic factors (weather, agrotechnics, soil). The two most frequently calculated yield functions are:

the average yield

$$q = q\,(M) + q\,(A) + q\,(F)_{max};\ \text{ma/ha} \tag{1}$$

the optimum yield

$$q_{opt} = q\,(M)_{max} + q\,(A) + q\,(F)_{max};\ \text{ma/ha} \tag{2}$$

In Equ. (1) and (2) the definitive equations and other components not included in the above are interpreted according to the breakdown model (ERDŐS 1978).

The breakdown model is based on the following considerations: the yearly fluctuation of yield averages is the consequence of yearly fluctuations in the weather conditions; the tendency of yield averages to increase in time is the consequence of the rise in the agrotechnical level with time; the direct effect of the soil is a constant value which does not change in time; the full effect of soil quality (direct + indirect) can only be assessed through comparative analyses.

Before working out the above equations the yield trend function $\overline{q}(t)$ must be produced from as long a yield data time series as possible. In a linear case this is

$$\overline{q}(t) = q_0 + bt\,, \quad b > 0 \tag{3}$$

where t is the time in years. In addition the upper enveloping function $q_{opt}(t)$ must be determined from some visually chosen, outstandingly high yield data and the lower enveloping function $q_{min}(t)$ from some visually chosen, outstandingly low yield data. After this, within an upper closed phase of the trend (5—10 years), the necessary definitive equations can be calculated for each year according to the interpretation below.

The full effect of weather fluctuation is

$$q(M)_{max} = q_{opt}(t_i) - q_{min}(t_i)\,. \tag{4}$$

The effect of weather fluctuation (or the direct effect of the weather) is

$$q(M) = q(t_i) - q_{min}(t_i)\,. \tag{5}$$

The yield loss caused by the weather is

$$H(M) = q_{opt}(t_i) - q(t_i)\,. \tag{6}$$

The effect of development in the agrotechnical level (or more simply, the effect of agrotechnics) is

$$q(A) = q_{min}(t_i) - q(F)_{max}\,. \tag{7}$$

The method for calculating the direct effect of the soil, $q(F)_{max}$, will be presented separately later. At an initial low level of cultivation the yield equation is

$$q_k = q(M) + q(A_k, F)\,, \tag{8}$$

from which

$$q(A_k, F) = q_k - q(M)\,. \tag{9}$$

If the effect of the initial level of agrotechnics is assumed to be negligibly small compared to the other components, then from Equ. (9) it can be seen that

$$q(A_k, F) \simeq q(F)_{max}\,. \tag{10}$$

The soil effect will subsequently be expressed from the approximation (10) on the basis of a hundred-year yield data time series.

For the analyses the following maize yield data were available from Békés county: county yield averages (1876—1975); yield averages for all the districts in Békés county and for the Mezőhegyes State Farm (1957—1975); the yield averages of the Orosháza, Békés and Szarvas districts, and of the Mezőhegyes State Farm from two periods (1927—1943) and (1947—1975); it should be noted that the data for the period 1943—1949 are missing from the county yield averages.

The yield data time series was processed in several different ways. The hundred-year county data were divided into three periods, and linear trends were calculated (1876—1912, 1910—1942, 1950—1975). The basic data were calculated according to the model, but they are always middle values for 5 years (e.g. 1880 for 1878—92), except that the 1975 value is taken for 1971—75 and the 1950 value for 1950—54 (due to lack of data). Mean values for five-year periods are also presented in the tables, figures and equations, if not otherwise indicated. For the purpose of comparison trend functions and the corresponding basic data were calculated for the following periods: 1957—75, from the data series of each district, together with the county data series and that of the Mezőhegyes State Farm; 1927—43 and 1947—75 from the data series of the Orosháza, Békés and Szarvas districts and of the Mezőhegyes State Farm.

Table 1

Development of maize yield structure over a

Year	q	$\bar{q}$	q_{opt}	q_{min}	q(M)
1880	14.7	13.3	18.0	6.4	8.3
1890	15.9	13.8	18.4	6.1	9.8
1900	12.5	14.2	18.9	5.9	6.6
1910	16.7	14.7	19.3	5.6	11.1
1920	12.1	15.4	21.4	6.8	5.3
1930	14.5	16.4	23.3	8.4	6.1
1940	17.5	17.2	25.2	10.0	7.4
1950	19.3	17.3	28.8	12.8	6.5
1960	27.2	28.4	37.4	21.6	5.6
1970	40.9	42.3	48.1	32.7	8.2
1975	49.6	46.5	51.8	37.5	12.2
Before World War I	14.9	14.0	18.6	6.0	8.9
Between World Wars I and II	14.7	16.3	23.3	8.4	6.3
after World War II	34.2	33.6	41.5	26.2	8.1

Development of yield structure in time

According to the yield equation the volume and structure of the yield depend on the weather conditions, the agrotechnical level and the quality of the soil. These factors change in time (there are also relative changes in the effect of the soil, which is considered to be constant), so the analysis of yield structure as a function of time is important.

The hundred-year basic data time series on yield components in Békés county is seen in Table 1. Three main periods are distinguished, that before World War I, that between World Wars I and II, and that after World War II. From the data in Table 1 yield equation combination can be formed at will if the effect of the soil factor is also separated. For the 1910s it is found from Equ. (10) that

$$q(A, F) = q(F)_{max} = 5.6 \quad (ma/ha)\,. \tag{11}$$

The 1910s were chosen instead of the initial period, the 1880s, because before World War I $q_{min}(t)$ showed a decreasing tendency (a rare exception). Below, the separate "pure" effect of agrotechnics for any period can be calculated in the following way:

$$q(A) = q_{min} - 5.6\,. \tag{12}$$

We are interested in the hundred-year changes in the following yield components (in relation to q): q(M), H(M), $q(M)_{max}$, q(A, F) and q(A). The development of the actual quantity of yield (q) has the following characteristics (Table 1, Figs. 1 and 2): the maize yield average has increased threefold in a hundred years; the increase in yield average is not the result of uniform development; before World War I the fluctuation in the yield was considerable and development was practically negligible (the trend was 0.045 ma/ha/year); between the two *hundred years (1876—1975, Békés county)*

H(M)	$q(M)_{max}$	q′(M)	H′(M)	$q'(M)_{max}$	q′(A, F)	$q'(F)_{max}$
3.2	11.5	0.566	0.219	0.639	0.434	0.381
2.5	12.3	0.616	0.155	0.668	0.384	0.352
6.4	13.0	0.530	0.512	0.688	0.470	0.448
2.6	13.7	0.665	0.156	0.710	0.335	0.335
9.3	14.6	0.435	0.771	0.682	0.565	0.463
8.8	14.9	0.412	0.606	0.639	0.588	0.386
7.7	15.1	0.425	0.439	0.599	0.575	0.320
9.5	16.0	0.337	0.494	0.555	0.663	0.290
10.2	15.8	0.207	0.375	0.422	0.793	0.206
7.2	15.4	0.200	0.176	0.320	0.800	0.137
2.1	14.3	0.246	0.042	0.276	0.756	0.113
3.7	12.6	0.594	0.261	0.676	0.403	0.379
8.6	14.8	0.424	0.605	0.640	0.576	0.390
7.3	15.4	0.248	0.272	0.393	0.753	0.187

world wars the development was very modest (0.09 ma/ha/year); if a linear trend were fitted for the period 1920—50 there would be a somewhat higher degree of development between the two world wars (Fig. 2); since World War II the yield development rate has been very fast (the trends are 1.39 and 1.59 ma/ha/year); since the yield averages before World War I and between the two world wars were identical (14.9; 14.7), the hundred-year increase in yield averages as a whole can be regarded as the result of development since World War II.

The changes in the yield-forming effect of weather show the following characteristics (Table 1). q(M): the direct effect of weather fluctuates considerably in time (due to the annual fluctuation in the weather), but does not show any definite development trend over the century as a whole; the same is characteristic of the behaviour of H(M); $q(M)_{max}$: the full effect of weather fluctuation indicates a slightly increasing tendency (World War II/World War I = 15.4/12.6 = 122%), which is negligible, however, compared to the increase in yield averages. The relative yield-forming effect of the weather definitely decreases in time, as proved by the mean values of q′(M) in the main periods (0.594; 0.424; 0.248); H′(M) is partly contradictory, but there is no justification for excluding it from the generalization; the values of $q'(M)_{max}$ also support the above conclusion.

As reflected in the above calculations, the development of the agrotechnical effect as a function of time is not a simple matter. Before World War I $q_{min}(t)$ showed a decreasing, and $\bar{q}(t)$ an increasing tendency. Both functions have very small slopes, but in absolute terms the trend is higher ($| 0.045 | > | -0.026 |$).

It is probable that $q_{min}(t)$ only shows a decreasing tendency by chance. This is quite conceivable considering the way in which it is determined; before World War I the agrotechnical level was practically constant with time, and no development of the agrotechnical effect at that time can be pointed out. The development of the agrotechnical effect throughout

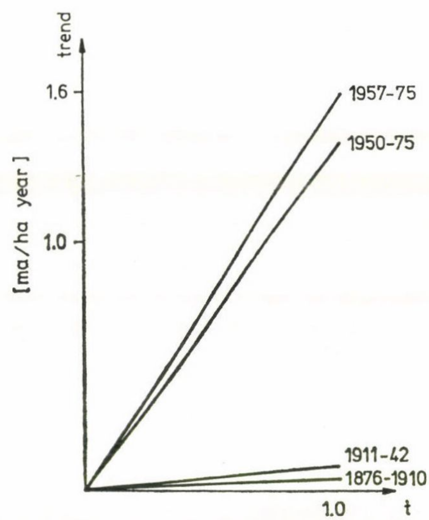


Fig. 1. Changes in maize yield trends over a hundred years. Békés county, 1876–1975

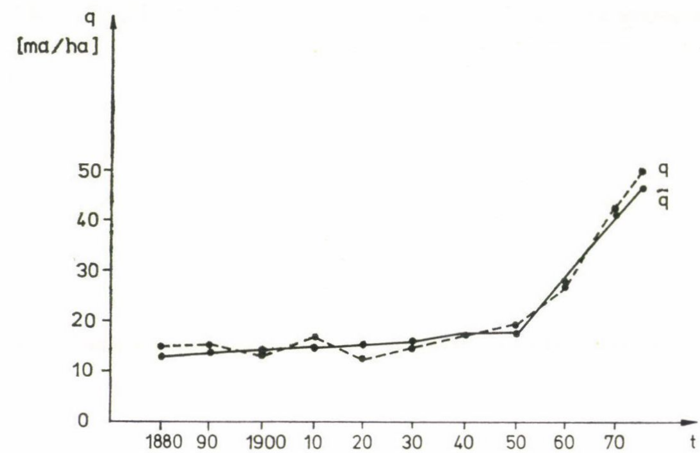


Fig. 2. Hundred-year development of maize yields on the basis of actual yield averages and yield trends. Békés county, 1876–1975

the century is, however, beyond question. The values of q′(A, F) in the main periods (0.403; 0.576; 0.753) suggest an intensive development. This is even more conspicuous in Fig. 3, which illustrates the increase in the "pure" agrotechnical effect as a function of time. The figure shows a parabola type of increasing function which proves that the development of the agrotechnical effect accelerates in time. According to our present theoretical knowledge this rate of development is only possible within a limited phase of development, that is, it is of a temporary character. From such empirical correlations extrapolated conclusions cannot (and must not) be drawn. From what has been said above it is evident that the agrotechnical effect plays a decisive (almost exclusive) role in the increase in yield averages.

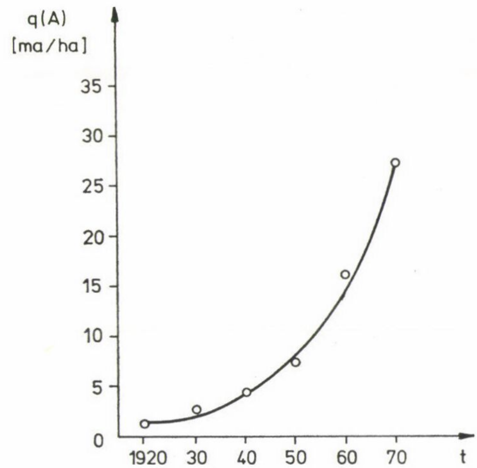


Fig. 3. Yield-forming effect of development in the agrotechnical level. Békés county, 1920—1970

It is easy to see that the effect of soil $q(F)_{max}$ is constant, while $q'(F)_{max}$ decreases if q increases in time.

Changes in the yield structure are best shown through the solutions of the yield function. Changes in the yield structure of maize in the main periods and in the most recent years expressed in the relative form of Equ. (1) are:

before World War I:	$q' = 1 = 0.597 + 0.027 + 0.376$
between World Wars I and II:	$q' = 1 = 0.429 + 0.190 + 0.381$
after World War II:	$q' = 1 = 0.237 + 0.602 + 0.164$
around 1975:	$q' = 1 = 0.246 + 0.643 + 0.113$

It can be seen from the above that radical changes in the yield structure have occurred during the last hundred years. The rate of change in the yield structure is equal to or even exceeds that in the quantity of yield. Before World War I the larger part (60%) of the average yield could be attributed to the direct effect of the weather. The effect of agrotechnical development was negligible (3%) and the effect of the soil comparatively high (37%). This proves that the old peasant saying ("weather is the boss") had a sound basis. The effect of agrotechnical development between the two world wars is apparent, though the effect of the weather was still the primary yield component at that time (43%). Since World War II (and particularly in recent years) the yield structure has radically changed. The effect of agrotechnical development (60—65%) is higher than the effect of the weather was before World War I. Today 24—25% of the average yield can be attributed to the direct effect of the weather. The effect of the soil is now only a minor component of the yield average.

While fluctuation in the weather was the main yield factor before World War I, today the agrotechnical level plays the decisive role. Nevertheless, the yield-forming effect of weather fluctuation has remained very important. In the case of extremely unfavourable weather conditions the average yield may be reduced by as much as 25%. In years with highly favourable weather conditions $[H'(M) = 7.3/34.2 = 0.213]$ a bumper yield, some 20% higher than the average, can be reckoned with. It can be said that at the present agrotechnical level fluctuation in the weather in extreme cases can cause at most $\pm 20\%$ yield fluctuations compared to the average maize yield of recent years, but the actual yield fluctuations will in all probability be much lower than that.

Changes in the optimum yield structure expressed from Equ. (2) in a relative form are:

before World War I:	$q'_{opt} = 1 = 0.677 + 0.022 + 0.301$
between World Wars I and II:	$q'_{opt} = 1 = 0.635 + 0.120 + 0.240$
after World War II:	$q'_{opt} = 1 = 0.371 + 0.496 + 0.135$
around 1975:	$q'_{opt} = 1 = 0.276 + 0.616 + 0.108$

The optimum yield, which can only be attained in years with highly favourable weather conditions, has a somewhat different structure than the average yield. In the optimum yield the absolute values of the agrotechnical and soil effects are identical with those in the average yield (i.e. they are relatively lower), but the effect of the weather is equal to the full effect of weather fluctuation, so both its absolute and relative values are higher than in the average yield. Before World War I two-thirds of the optimum yield (67.7%) was due to the full effect of weather fluctuation, while since World War II the corresponding proportion is only about one-third (37.1—27.6%). The agrotechnical effect has recently reached 60% (61.6%), while the soil effect is hardly more than 10%. There is more similarity than difference between the structures of the average and optimum yields.

Relations between yield components

The time functions of various yield component combinations (ratios) are presented in a number of figures. Changes in the minimum/optimum yield ratio as a function of time are described by a non-linear increasing function (Fig. 4). The ratio of q_{min}/q_{opt} increased from 1/3 to 2/3 in the 50 years from 1920—1970. From this the following conclusions can be drawn: when the agrotechnical level rises $q_{min}(t)$ and $q_{opt}(t)$ show increasing tendencies but $q_{min}(t)$ increases much faster; between 1880 and 1970 q_{min} increased fivefold ($32.7/6.4 = 5.109$), and q_{opt} hardly threefold ($48.1/18.0 = 2.672$); thus the agrotechnical level has more effect on the development of the minimum yield (and thus on the reliability of production) than on the development of average and optimum yields (which have more or less the same rate of development); in principle it is obvious that this rapid development in the q_{min}/q_{opt} ratio can only be temporary (q_{min}/q_{opt} is necessarily less than 1, because $q_{min}/q_{opt} = 1$ would mean a complete elimination of the weather effect).

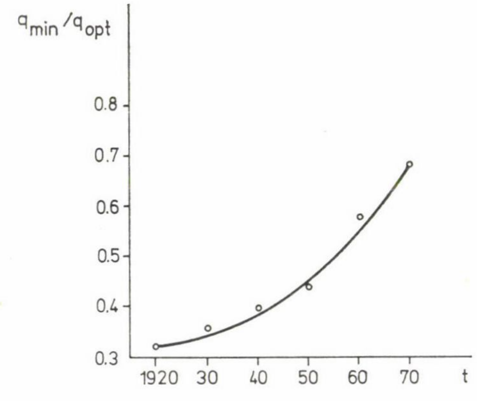


Fig. 4. Increase in time of the relative index of production reliability (q_{min}/q_{opt}). Békés county, 1920—1970

From Figs. 5, 6 and 7 (compared with Fig. 3) several important conclusions can be drawn. The weather/agrotechnical effect ratio is a non-linear function decreasing in time (Fig. 5). Since we know that q(M) is stagnant or rises slightly in time, the character of the above relationship is determined by the very fast development rate of the agrotechnical effect (Fig. 3). Earlier (before World Wars I and II) the agrotechnical development was slight, so the effect of the weather in that period seems to have been enormously high. At present the value of the q(M)/q(A) ratio is about 0.3. It follows from the character of the function that the ratio of q(M) to q(A) will become more and more "stabilized". The function shown in Fig. 6 emphatically confirms the above statements. Fig. 7 is an analogue of Fig. 6, where the "pure" agrotechnical effect is replaced by q(A, F) in the denominator. Thus a linear decreasing function is obtained, which does not give rise to any contradiction to the above statements (Fig. 7). If it were plotted it would be seen that q(M)/q(A, F) forms a linear decreasing function similar to Fig. 7.

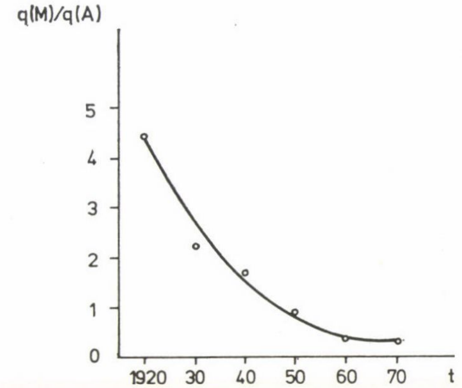


Fig. 5. Relative decrease in the effect of weather on maize yields as a function of time. Békés county, 1920—1970

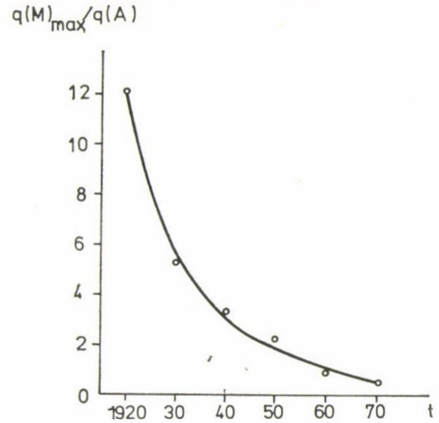


Fig. 6. Decrease in time of the full effect of weather fluctuation as compared to the agrotechnical effect. Békés county, 1920—1970

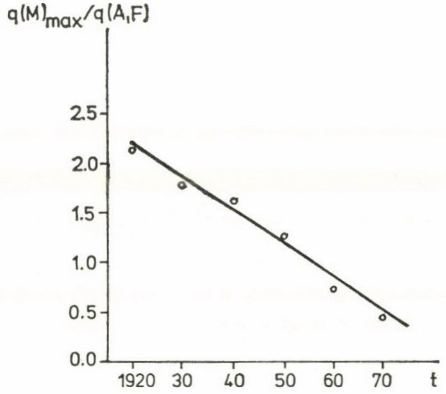


Fig. 7. Development in the structure of optimum maize yields. Békés county, 1920—1970

Effect of soil quality

Both direct and indirect effects of the soil quality are evident in the amount and structure of the yield. Let us try to assess and analyse the two kinds of effect separately.

From the data series the districts in Békés county and the Mezőhegyes State Farm were listed in order of soil quality: Mezőhegyes (very good), Orosháza (good), Gyula (medium), Szeghalom (poor). In Fig. 8 the comparison of trends shows them in decreasing order. On comparing Fig. 1 with Fig. 8 it can be seen that as the soil quality increases the distribution of

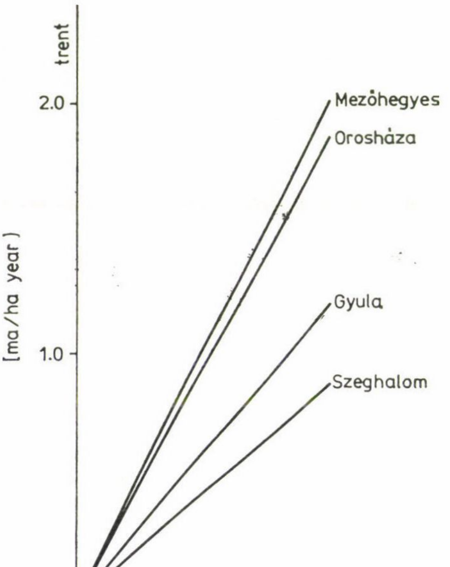


Fig. 8. Comparison of maize yield trends according to soil quality. Békés county, 1957—1975

trends shows a pattern characteristic of the development in yield throughout the century. In other words, the yield average on a poor quality soil has increased in recent years at the same rate as it did on a better quality soil some time back. This must definitely be regarded as a soil effect, i.e. as the indirect effect of soil quality, or the interaction of soil and agrotechnics. However, this statement only holds true if it is assumed that the agrotechnical level was the same for all types of soil (in each district) in recent years, or that differences were only due to differences in soil quality. A simple calculation shows that the greatest difference in trend (between Mezőhegyes and Szeghalom) caused by the soil quality in recents years corresponds to 2/3—3/4 (1.117/1.545 = 0.723) of the hundred-year trend in the county (1.590—0.045).

Table 2

Comparison of yield functions and yield component ratios in maize according to soil quality, on the basis of average values for the 1960s + 1970s. Békés county

Districts	q	$q'(M)$	$q'(A, F)$	q_{opt}	$q'(M)_{max}$	$q'(A, F)$	$\frac{q(M)}{q(A, F)}$	$\frac{q(M)_{max}}{q(A, F)}$
County	34.05	0.273	0.727	39.05	0.366	0.634	0.376	0.578
Mezőhegyes	48.70	0.223	0.777	60.75	0.377	0.623	0.287	0.605
Orosháza	36.10	0.224	0.776	46.15	0.391	0.607	0.289	0.645
Gyula	31.40	0.290	0.710	38.10	0.413	0.588	0.408	0.703
Szeghalom	22.25	0.609	0.391	30.75	0.717	0.283	1.557	2.534

The soil effect can be examined more closely by writing down the yield functions in order of soil quality, as seen in Table 2. It can be seen that as the soil quality decreases q, q_{opt} and both values of $q'(A, F)$ decrease, while $q'(M)$ and $q'(M)_{max}$ show increasing tendencies; the values for the medium soil quality in Gyula district differ only slightly from those for good soils, while those of the Szeghalom district are always conspicuously different; in the Szeghalom district the yield average is higher today than the county yield averages were before World War I, but the structure of the yield (both average and optimum) is surprisingly similar to the county yield structure before World War I; in the yields of the Szeghalom district the effect of weather fluctuation (0.609 and 0.717) is still a decisive factor, while $q'(A, F)$ is so low that it cannot be attributed to a lower direct effect of the soil (as will be seen later), and even less so to a possible backwardness of the agrotechnical level. The yield structure of the Szeghalom district is theoretically a typical phenomenon. The soil is a yield factor which is at a relative minimum and thus strongly limits the dynamic optimum of the agrotechnical effect (and in part even that of the weather effect).

For the sake of completeness the direct effect of the soil must also be determined according to the soil quality. From the short trend functions available (1957—1975) the actual values of $q(F)_{max}$ cannot be calculated. However, estimates can be produced for $q(F)_{max}$ on the basis of the following assumptions: (1) that with each kind of soil $q(F)_{max}/q(A, F)$ decreases in time at the same rate as it does in the county as a whole (Fig. 9); (2) that $q(F)_{max}/q(A, F)$ for each kind of soil decreases in time in proportion to the county/district trends. On the basis of mean values for the 1960s + 1970s the estimated values of $q(F)_{max}$ were determined for each kind of soil and each district using the two assumptions (Table 3). The methods of calculation using assumptions (1) and (2) are:

$$q_1(F)_{max} = 0.215\ q(A, F)\,, \tag{13}$$

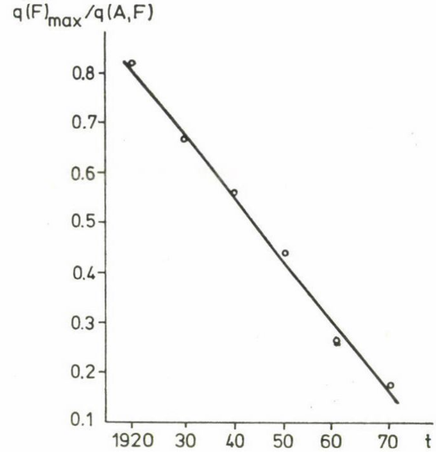


Fig. 9. Relative decrease in the direct effect of soil on maize yields. Békés county, 1920—1970

Table 3

Changes in the effects of agrotechnical level and soil on maize yield according to soiln quality, on the basis of average data for the 1960s + 1970s. Békés county

Districts	Trend	k	$q(A, F)$	$q_1(F)_{max}$	$q_2(F)_{max}$	$q(A)$	$\frac{q_2(F)_{max}}{q(A, F)}$
County	1.590	1.000	24.75	5.32	5.32	19.43	0.215
Mezőhegyes	2.000	0.795	37.85	8.14	6.47	31.38	0.171
Orosháza	1.890	0.841	28.00	6.02	5.06	22.94	0.181
Gyula	1.200	1.325	22.40	4.79	6.35	16.05	0.285
Szeghalom	0.883	1.807	8.70	1.87	3.38	5.32	0.389

$$q_2(F)_{max} = 0.215 \text{ k } q(A, F)\,, \tag{14}$$

in which the county $q(F)_{max}/q(A, F) = 0.215$, and k is the ratio of county/district trends.

On the basis of Table 3 an overall view of the yield structures for different kinds of soil can be obtained. According to assumption (1) the calculated values of the soil effect, $q_1(F)_{max}$, form an unbroken decreasing series, though the differences are extreme. A series of $q_2(F)_{max}$ values seems to be a more rational estimate. The disturbing thing here is that higher values were obtained in the Gyula district than in the Orosháza district. In longer trends this contradiction would probably be eliminated. The ratio of the extreme values (between Szeghalom and Mezőhegyes) is approximately 1/2. It can be seen that these results were obtained by bold extrapolations carried out in several stages. From such results conclusions should only be drawn very carefully and with certain reservations, and these conclusions are only satisfactory as long as adequate results are not available from direct comparative calculations.

After the separation of q(A) the full three-component yield functions for each kind of soil can be written down. Only the yield functions of extreme types of soils are compared, in the absolute and relative forms. From Equ. (1), on the basis of the averages for the 1960s + 1970s,

$$\text{Mezőhegyes: } 48.70 = 10.85 + 31.38 + 6.47;$$
$$1 = 0.223 + 0.644 + 0.133$$
$$\text{Szeghalom: } 22.25 = 13.55 + 5.32 + 3.38;$$
$$1 = 0.609 + 0.239 + 0.152.$$

The Szeghalom/Mezőhegyes yield component ratios are as follows: the average yield is, less than 1/2, the effect of the weather is greater than 1, the agrotechnical effect is about 1/6, and the direct effect of the soil is approximately 1/2. By summing up the above results noteworthy conclusions can be drawn: at the present agrotechnical level the direct yield-forming effect of the soil is a minor factor in the yield (10—20%); the direct effect of the soil (in absolute and relative terms) varies greatly with the kind of soil, though from the point of view of the amount of yield this is not important; if the soil is a minimum factor relative to the other yield factors, then the full (direct + indirect) effect of the soil may play a decisive, definitive role in the yield. If the soil factor is at a relative minimum, it theoretically limits both the weather and the agrotechnical effects, though the latter is affected to a much greater extent. This last statement only holds true with certain reservations.

Conclusions

The analysis of maize yield data time series clearly shows that the breakdown model applied here can be used to advantage in practice and is suitable for the achievement of new scientific results.

Maize yield averages have increased about threefold in the last hundred years and the yield structure has also changed radically. The main characteristics of the yield structure are that before World War I the effect of weather fluctuation was the decisive factor (60%), the effect of agrotechnical development was negligible, and the direct yield-forming effect of the soil was nearly 40%. In recent years these ratios, given in the same order, have become 25 + 64 + 11%.

The effect of weather fluctuation on the maize yield (in absolute terms) is more or less constant, or only increases slightly. The relative effect of the weather, on the other hand, definitely decreases in time as the agrotechnical level rises. At the present agrotechnical level fluctuations in the weather, even in extreme cases, can cause at most a ±20% fluctuation in the yield. In Békés county at least 75.6% of the maize yield average can now be taken as "guaranteed" every year. Before World War I the "guaranteed" proportion of the yield was only 40%.

Thus the development of the agrotechnical level not only increases maize yield averages but also improves the reliability of production.

The quality of the soil has a direct and indirect effect on the yield. It influences the size of the yield, the rate of development (the trend), and the yield structure. On poor quality soil the yield is considerably smaller, the rate of development is slower, and the yield structure is similar to what it was earlier on better quality soil at a lower agrotechnical level. In the case of highly unfavourable soil conditions the effect of weather fluctuations is still a decisive factor in the yield.

The full effect of the soil is always an important yield factor; the indirect effects of the soil (manifesting themselves through the agrotechnical and weather effects) may be much greater than the direct ones.

*

Prepared at the Meteorological Department of the Eötvös Loránd University, Budapest.

L. Erdős

References

Erdős, L. (1976): A termés szétbontása a környezeti tényezők hatásainak arányai szerint (Breakdown of yield as a ratio of the effects of environmental factors). Földrajzi Értesítő, XXV/1, 61–79.

Erdős, L. (1980): Módszer a termésátlag szerkezetének a tanulmányozásához (Method for studying the structure of the yield average). Acta Agron. Hung. (in press).

VIRUSES OF LETTUCE

I. Natural Occurrence — A Review

Investigations related with the virus diseases of lettuce (*Lactuca sativa* L.) have been carried out for some six decades. It was in the United States of America that the occurrence of the lettuce mosaic disease was first pointed out (Jagger 1921). This infectious disease was later found to be caused by a virus spread by lettuce seed and aphids in a stylet-borne manner. The legitimate name and the cryptogram of the virus known earlier by the scientific name of *Lactuca* virus 1, then as *Marmor lactucae* Holmes are: lettuce mosaic virus, $^{*}/_{*}$: $^{*}/_{*}$: E/E : S/Ap; potyvirus group.

Since its discovery the lettuce mosaic virus, a member of the potyvirus group (subdivision-II, cf. Tomlinson 1970, Harrison *et al.* 1971, Edwardson 1974a, b, Christie—Edwardson 1977) has spread all over the world and causes serious economic losses. In Europe it appeared in the thirties, supposedly due to the introduction of virus-infected seed (Broadbent *et al.* 1951). Between 1950 and 1960 the extent of infection in some European countries was almost 100%, and, as a consequence, lettuce production was sharply reduced (Bremer 1952, Ullrich 1954).

After its previous sporadical occurrence the lettuce mosaic virus assumed increasing importance in Hungary in the fifties, although its distribution in the country was still not general (Szirmai 1957). Characteristically of the subsequent spread of the lettuce mosaic virus in Hungary, the seed of the varieties *Lactuca sativa* cvs. Cobham Green, Unrivalled, All The Year Round exported to England proved highly infected compared to the seed of the same lettuce varieties imported into England from the United States of America (Hall—Bennett 1970).

Considering that in the relevant Hungarian literature information on studies related with the lettuce mosaic virus is only given by a single author (Szirmai 1957). It was thought necessary to sum up our knowledge of the virus pathogens of lettuce and to give an account of the results of recent investigations concerning the isolation, identification and host range of lettuce mosaic virus and cucumber mosaic virus (R/1 : 1/18 : S/S : S/Ap; cucumovirus group), both isolated from lettuce, as well as the separation of the virus pathogens of lettuce.

In the first part of this series of publications the viruses that occur in lettuce and cause considerable economic losses will be described. In the second paper the full range of natural and artificial host plants of lettuce mosaic virus and cucumber mosaic virus will be presented, as well as the resistant plants. In the third part of the series of papers the research work related with the identification of lettuce mosaic virus and cucumber mosaic virus, both isolated from lettuce will be described, and the results will be published. In the fourth and last part of the series the possibilities for separating the virus pathogens of lettuce will be dealt with, and a method enabling the virus pathogens of lettuce to be identified will be described.

Table 1

Natural occurrence of viruses on lettuce (Lactuca sativa L.)

Viruses	Countries	References
Arabis mosaic virus	England	WALKEY (1967), RAGOZZINO *et al.* (1971)
Beet western yellows virus	United States of America	DUFFUS (1960), ZINK—DUFFUS (1972)
	German Federal Republic	NAGI (1975)
Beet yellow stunt virus	United States of America	DUFFUS (1964)
Bidens mottle virus	United States of America	CHRISTIE *et al.* (1968), PURCIFULL *et al.* (1971), ZITTER—GUZMAN (1974)
Broad bean wilt virus	German Democratic Republic	GIPPERT—SCHMELZER (1975)
	United States of America	BRUCKART—LORBEER (1975)
	France	MARROU *et al.* (1976)
	German Federal Republic	WEIDEMANN (1977)
Cucumber mosaic virus	New Zealand	THOMSON—PROCTER (1965)
	Italy	RAGOZZINO *et al.* (1971), CANNIZZARO *et al.* (1975)
	German Democratic Republic	GIPPERT (1973)
	German Federal Republic	WEIDEMANN—ROHLOFF (1976)
Lettuce big vein virus	United States of America	CAMPBELL *et al.* (1961), LIN *et al.* (1970)
Lettuce mosaic virus	United States of America	JAGGER (1921), GROGAN *et al.* (1952, 1955), COSTA—DUFFUS (1958), McLEAN—KINSEY (1962), DUFFUS *et al.* (1970), PURCIFULL—ZITTER (1971), PROVVIDENTI—SCHROEDER (1972), PROVVIDENTI (1973), ZINK—DUFFUS (1972)
	England	KASSANIS (1947), BROADBENT *et al.* (1951), TOMLINSON (1970)
	Belgium	BOXUS (1964), VERHOYEN (1965)
	Czechoslovakia	CHOD *et al.* (1973), POLÁK *et al.* (1974)
	France	MARROU (1960, 1961)
	The Netherlands	Van HOOF (1956, 1959)
	Israel	NITZANY—COHEN (1963), NITZANY—MARROU (1970), NITZANY (1975)
	Yugoslavia	ŠTEFANAC—MAMULA (1976), ŠARIĆ—WRISHER (1977)
	Hungary	SZIRMAI (1957), HORVÁTH (1979)
	German Democratic Republic	GIPPERT (1973), SCHMELZER *et al.* (1977)
	German Federal Republic	ULLRICH (1954), KEMPER (1962), HEIN (1976), WEIDEMANN—ROHLOFF (1976) (1971)
	Italy	MARINI (1955), RAGOZZINO *et. al.* (1971)
	Switzerland	PELET (1964)

Viruses	Countries	References
	New Zealand	FRY (1952)
Lettuce necrosis virus	England German Federal Republic	KASSANIS (1947) HEIN (1963)
Lettuce necrotic yellows virus	Australia New Zealand	STUBBS—GROGAN (1963), RANDLES—CROWLEY (1970), RANDLES—CARVER (1971), FRANCKI—RANDLES, (1970), BOAKYE—RANDLES (1974) FRY *et al.* (1973)
Sowthistle yellow vein virus	United States of America	DUFFUS *et al.* (1970)
Strawberry latent ringspot virus	England	COCK (1968)
Tobacco necrosis virus	Belgium Italy	VERHOYEN (1965) RAGOZZINO *et al.* (1971)
Tobacco rattle virus	The Netherlands United States of America	DROST (1965) MAYHEW—MATSUMOTO (1978)
Tomato black ring virus	England France	SMITH—SHORT (1959) MORAND—POUTIER (1978)
Tomato spotted wilt virus	German Democratic Republic	SCHMELZER—WOLF (1971)
Turnip mosaic virus	United States of America	PURCIFULL (1968)

Natural occurrence of viruses in lettuce
(Lactuca sativa L.)

According to our present knowledge the natural occurrence in lettuce of some 17 viruses transmissible by aphids, nematodes, thripses, soil-borne fungi, seed of infected plants and mechanically has been pointed out so far (Table 1). Lettuce mosaic virus is the most widespread and economically most important virus of the lettuce plant. Among the aphid-transmitted, stylet-borne spherical viruses recently occurring in lettuce in simplex and complex forms the cucumber mosaic virus and broad bean wilt virus (R/1 : */33 : S/S : S/Ap) are undoubtedly the most important ones (GIPPERT 1973, BRUCKART—LORBEER 1975, GIPPERT—SCHMELZER 1975, MARROU *et al.* 1976, WEIDEMANN 1977). Each of the latter two viruses has a wide host range, and many overwintering hosts are known. According to our experiments under Hungarian conditions important overwintering host plants are *Brassica napus*, *Paulownia imperialis*, *Catalpa bignonioides*, *Circaea lutetiana*, *Stellaria media* and *Echinocystis lobata* (HORVÁTH 1976); seeds of the latter two plants play an important role in spreading the cucumber mosaic virus. In the distribution of broad bean wilt virus in lettuce crops various virus-susceptible vegetables (e.g. *Daucus carota*, *Petroselinum crispum*) and *Tropaeolum majus*, a popular ornamental plant in small gardens, which according to literary data are sources of broad bean wilt virus, are supposed to play some part (SCHMELZER—WOLF 1969, WOLF 1970, FROWD—TOMLINSON 1972a, b, WOLF—SCHMELZER 1972, SHUKLA—SCHMELZER 1972, 1973a, b, HORVÁTH—SZIRMAI 1975).

*

Prepared at the Institute for Plant Protection, University of Agricultural Sciences, Keszthely.

J. HORVÁTH

References

BOAKYE, D. B.—RANDLES, J. W. (1974): Epidemiology of lettuce necrotic yellows virus in South Australia. Virus transmission parameters, and vector feeding behaviour on host and non-host plants. Austr. J. Agr. Res., **25**, 791—802.

BOXUS, P. (1964): Experiments on the mechanical transmission of lettuce mosaic. Meded. Landbouwh. Gent., **29**, 926—932.

BREMER, H. (1952): Salatmosaik. Ein Sammelbericht. Z. PflKrankh., **59**, 275—277.

BROADBENT, L.—TINSLEY, T. W.—BUDDIN, W.—ROBERTS, E. T. (1951): The spread of lettuce mosaic virus in the field. Ann. Appl. Biol., **38**, 689—706.

BRUCKART, W. L.—LORBEER, J. W. (1975): Recent occurrence of cucumber mosaic, lettuce mosaic and broad bean wilt viruses in lettuce and celery fields in New York. Plant Dis. Rep., **59**, 203—206.

CAMPBELL, R. N.—GROGAN, R. G.—PURCIFULL, D. E. (1961): Graft transmission of big vein of lettuce. Virology, **15**, 82—85.

CANNIZZARO, G.—ROSCIGLIONE, B.—RUSSO, M. (1975): Mixed infections of lettuce mosaic and cucumber mosaic viruses on *Lactuca* spp. in Sicily. Phytopath. Medit., **14**, 113—118.

CHOD, J.—POLÁK, J.—NOVÁK, M.—JOKES, M. (1973): Intracytoplasmic inclusions in cells of lettuce leaves with mosaic-like symptoms. Biol. Plant., **15**, 208—216.

CHRISTIE, R. G.—EDWARDSON, J. R. (1977): Light and electron microscopy of plant virus inclusions. Florida Exp. Stat. Monograph. Ser., **9**, 1—150.

CHRISTIE, S. R.—EDWARDSON, J. R.—ZETTLER, F. W. (1968): Characterization and electron microscopy of a virus isolated from *Bidens* and *Lepidium*. Plant Dis. Rep., **52**, 763—768.

COCK, L. J. (1968): Virus diseases of lettuce. N.A.A.S. Quart. Rev., **79**, 126—138.

COSTA, A. S.—DUFFUS, J. E. (1958): Observations on lettuce mosaic in California. Plant Dis. Rep., **42**, 583—586.

DROST, H. J. M. (1965): Enkele nieuwe virusziekten bij sla en komkommer. Optreten en symptomen. Neth. J. Pl. Pathol., **71**, 60.

DUFFUS, J. E. (1960): Two viruses that induce symptoms typical of June yellows in lettuce. Plant Dis. Rep., **44**, 406—408.

DUFFUS, J. E. (1964): Beet yellow stunt virus. Phytopathology **54**, 1432 (Abstr.).

DUFFUS, J. E.—ZINK, F. W.—BARDIN, R. (1970): Natural occurrence of sowthistle yellow vein virus on lettuce. Phytopathology, **60**, 1383—1384.

EDWARDSON, J. R. (1974a): Some properties of the potato virus Y-group. Florida Agr. Exp. Stat., Monograph. Ser., **4**, 1—398.

EDWARDSON, J. R. (1974b): Host ranges of viruses in the PVY-group. Florida Agr. Exp. Stat., Monograph. Ser., **5**, 1—225.

FRANCKI, R. I. B.—RANDLES, J. W. (1970): Lettuce necrotic yellows virus. C.M.I./A.A.B. Description of plant viruses. No. 26.

FROWD, J. A.—TOMLINSON, J. A. (1972a): The isolation and identification of parsley viruses occurring in Britain. Ann. Appl. Biol., **72**, 177—188.

FROWD, J. A.—TOMLINSON, J. A. (1972b): Relationships between a parsley virus, nasturtium ringspot virus and broad bean wilt virus. Ann. Appl. Biol., **72**, 189—195.

FRY, P. R. (1952): Lettuce mosaic. N. Z. J. Sci. Techn., Sect. A., **33**, 52—63.

FRY, P. R.—CLOSE, R. C.—PROCTER, C. H.—SUNDE, R. (1973): Lettuce necrotic yellows virus in New Zealand. J. Agr. Res., **16**, 143—146.

GIPPERT, R. (1973): Gurkenmosaik-Virus als Ursache von Mosaikerscheinungen an Salat. Gartenbau, **20**, 55.

GIPPERT, R.—SCHMELZER, K. (1975): Natürlicher Befall durch das Ackerbohnenwelke-Virus beim Kopfsalat (*Lactuca sativa* L.). Zbl. Bakt. Abt. II. **130**, 11—14.

GROGAN, R. G.—WELCH, J. E.—BARDIN, R. (1952): Common lettuce mosaic and its control by the use of mosaic-free seed. Phytopathology, **42**, 573—578.

GROGAN, R. G.—SNYDER, W. C.—BARDIN, R. (1955): Diseases of lettuce. Calif. Agr. Exp. Stat. Cir., **448**, 1—28.

HALL, C. M.—BENNETT, A. H. (1970): Incidence of lettuce mosaic virus in imported lettuce seed. Plant Pathol., **19**, 194—195.

HARRISON, B. D.—FINCH, J. T.—GIBBS, A. J.—HOLLINGS, M.—SHEPHERD, R. J.—VALENTA, V.—WETTER, C. (1971): Sixteen groups of plant viruses. Virology, **45**, 356—363.

HEIN, A. (1963): Über ein Vorkommen des Salatnekrosevirus in Westdeutschland. Nachrichtenbl. Deut. Pflanzenschutzd., **15**, 17—20.

HEIN, A. (1976): Viruskrankheiten bei Kopfsalat. Gartenbau, **30**, 692—694.

HORVÁTH, J. (1976): Vírus-gazdanövénykörök és vírusdifferenciálás (Virus host plants and virus differentiation). Akad. Dokt. Ért., Budapest—Keszthely.

Horváth, J. (1979): New artificial hosts and non-hosts of plant viruses and their role in the identification and separation of viruses. VIII. Potyvirus group (Subdivision-II): Bean yellow mosaic virus and lettuce mosaic virus. Acta Phytopath. Hung., **14**, in press.

Horváth, J.—Szirmai, J. (1975): *Tropaeolum majus* L. a natural host plant of nasturtium ringspot virus in Hungary. Phytopath. Z., **82**, 122—127.

Jagger, I. C. (1921): A transmissible mosaic disease of lettuce. J. Agr. Res., **20**, 737—740.

Kassanis, B. (1947): Studies on dandelion mosaic and other virus diseases of lettuce. Ann. Appl. Biol., **34**, 412—421.

Kemper, A. (1962): Zum Auftreten von Salatmosaikvirus an Salat (*Lactuca sativa* L.) und an Kreuzkraut (*Senecio vulgaris* L.). Z. PflKrankheiten, **69**, 653—663.

Lin, M. T.—Campbell, R. N.—Smith, P. R.—Temmink, J. H. M. (1970): Lettuce big vein virus transmission by single sporangium isolates of *Olpidium brassicae*. Phytopathology, **60**, 1630—1634.

Marini, E. (1955): Una virosi transmessa per seme: Il mosaico della lattuga. Riv. Ortofloro-fruttic. Ital., **39**, 449—454.

Marrou, J. (1960): Inoculation méchanique du virus de la mosaïque de la laitue. Et. Virol. Appl., **1**, 2.

Marrou, J. (1961): Rôle des traitments aphicides dans la lutte contre la mosaïque de laitue et culture maraichère. Et. Virol. Appl., **2**, 71—77.

Marrou, J.—Duteil, M.—Leclant, F.—Cadilhac, B.—Esvan, C. (1976): Demonstration of broad bean wilt virus (BBWV) in lettuce with mottle symptoms. Ann. Phytopath. *8*, 461—469.

Mayhew, D. E.—Matsumoto, T.T. (1978): Romaine lettuce, a new host for tobacco rattle virus. Plant Dis. Rep., **62**, 553—556.

McLean, D. L.—Kinsey, M. G. (1962): Three variants of lettuce mosaic virus and methods utilized for differentiation. Phytopathology, **52**, 403—406.

Morand, J. C.—Poutier, J. C. (1978): Les taches en anneaux de la laitue, une souche du "tomato black ring virus". Ann. Phytopathol., **10**, 101—102.

Nagi, A. (1975): Beitrag zum vermutlichen Vorkommen des beet western yellows virus (BWYV) in Europa. Phytopath. Z. **82**, 146—151.

Nitzany, F. E. (1975): Review of vegetable virus diseases in Israel and their control. Plant Prot. Bull., **23**, 148—156.

Nitzany, F. E.—Cohen, S. (1963): The use of lettuce seed free of lettuce mosaic virus in Israel. Phytopath. Medit., **2**, 299—300.

Nitzany, F. E.—Marrou, J. P. (1970): Virus diseases of vegetable plants in the Mediterranean region. Phytopath. Medit., **9**, 66—70.

Pelet, F. (1964): La mosaïque de la laitue à l'étranger et en Suisse. Observations sur la situation sanitaire et le comportment des variétés de laitues. La Recherche Agr., **3**, 182—222.

Polák, J.—Chod, J.—Jokes, M. (1974): Checking of the reliability of the transmission of the lettuce mosaic virus by means of mechanical inoculation and testing for the presence of the virus in the seeds of some lettuce varieties. Védecké Práce, **19**, 5—10.

Provvidenti, R. (1973): Occurrence of lettuce mosaic virus in *Pisum sativum*. Plant Dis. Rep., **57**, 688—690.

Provvidenti, E.—Schroeder, W. T. (1972): Natural infection of *Spinacia oleracea* by lettuce mosaic virus. Plant Dis. Rep., **56**, 281—284.

Purcifull, D. E. (1968): Occurrence of a turpip mosaic virus in Florida. Plant Dis. Rep., **52**, 759—760.

Purcifull, D. E.—Zitter, T. A. (1971): Virus diseases affecting lettuce and endive in Florida. Florida State Hort. Soc., **84**, 165—168.

Purcifull, D. E.—Christie, S. R.—Zitter, T. A.—Bassett, M. J. (1971): Natural infection of lettuce and endive by bidens mottle virus. Plant Dis. Rep., **55**, 1061—1064.

Ragozzino, A.—Caia, R.—Xafis, C. (1971): I virus patogeni della lattuga in Campania. Riv. Ortoflorofruttic. Ital., **4**, 356—376.

Randles, J. W.—Crowley, N. C. (1970): Epidemiology of lettuce necrotic yellows virus in South Australia. I. Relationship between disease incidence and activity of *Hyperomyzus lactucae* (L.). Austr. J. Agr. Res., **21**, 447.

Randles, J. W.—Carver, M. (1971): Epidemiology of lettuce necrotic yellows virus in South Australia. II. Distribution of virus, host plants and vectors. Austr. J. Agr. Res., **22**, 231.

Šarić, A.—Wrisher, M. (1977): The effect of lettuce mosaic virus on plant cells. Phytopath. Z., **90**, 27—30.

Schmelzer, K.—Wolf, P. (1969): Nachweis des Ringmosaik-Virus der Kapuzinerkresse (nasturtium ringspot virus) in Trompetenbaum (*Catalpa bignonioides* Walt.) und Möhre (*Daucus carota* L.). Zbl. Bakt. Abt., II., **123**, 577—579.

SCHMELZER, K.—WOLF, P. (1971): Wirtspflanzen der Viren und Virosen Europas. Johann Ambrosius Barth, Leipzig 1971.
SCHMELZER, K.—WOLF, P.—GIPPERT, R. (1977): Gemüsepflanzen. In: KLINKOWSKI,' M. *et al.*: Pflanzliche Virologie. Band 3., Die Virosen an Gemüsepflanzen, Obstgewächsen und Weinreben in Europa. Akademie Verlag, Berlin 1977. 1—138.
SHUKLA, D. D.—SCHMELZER, K. (1972): Studies on viruses and virus diseases of cruciferous plants. III. Nasturtium ringspot virus in *Sinapis alba* L. Acta Phytopath. Hung., **7**, 147—156.
SHUKLA, D. D.—SCHMELZER, K. (1973a): Studies on viruses and virus diseases of cruciferous plants. XIV. Cucumber mosaic virus in ornamental and wild species. Acta Phytopath. Hung., **8**, 149—155.
SHUKLA, D. D.—SCHMELZER, K. (1973b): Studies on viruses and virus diseases of cruciferous plants. XIII. Cabbage black ring, nasturtium ringspot and alfalfa mosaic viruses in ornamental and wild species. Acta Phytopath. Hung., **8**, 139—148.
SMITH, K. M.—SHORT, M. E. (1959): Lettuce ringspot: a soil borne virus disease. Plant Pathol., **8**, 54—56.
ŠTEFANAC, Z.—MAMULA, D. (1976): Identification of lettuce mosaic virus in lettuce in *Croatia*. Zastita bilja, **27**, 279—288.
STUBBS, L. L.—GROGAN, R. G. (1963): Necrotic yellows: A newly recognised virus disease of lettuce. Austr. J. Agr. Res., **14**, 439.
SZIRMAI, J. (1957): A salátamozaik meghonosodása Magyarországon (The introduction of lettuce mosaic virus in Hungary). Növénytermelés, **6**, 225—232.
THOMSON, A. D.—PROCTER, C. H. (1965): Cucumber mosaic virus in lettuce. N.Z. J. Agr. Res., **9**, 142—144.
TOMLINSON, J. A. (1970): Lettuce mosaic virus. C.M.I./A.A.B. Description of plant viruses. No. 9.
ULLRICH, J. (1954): Untersuchungen über Salatmosaik. Nachrichtenbl. Deut. Pflanzenschutzd., **6**, 182—184.
Van HOOF, H. A. (1956): Verschil in reactie van wilds sla ten opzichte van besmetting hat slamozaiek virus. Tijdschr. Pl. ziekten, **62**, 285—290.
Van HOOF, H. A. (1959): Seed transmission of lettuce mosaic virus in *Lactuca serriola*. Tijdschr. Pl. ziekten, **65**, 44—46.
VERHOYEN, M. (1965): Identification de certains virus de la laitue en Belgique. Meded. Landbouwh. Gent., **30**, 1728—1742.
WALKEY, D. G. (1967): Chlorotic stunt of lettuce caused by arabis mosaic virus. Plant Pathol., **16**, 20—23.
WEIDEMANN, H. L. (1977): Untersuchungen zur Anfälligkeit von Salatmosaikvirusrezistentem Kopfsalat für Gurkenmosaik- und Ackerbohnenwelkevirus. Nachrichtenbl. Deut. Pflanzenschutzd., **29**, 99—101.
WEIDEMANN, H. L.—ROHLOFF, H. (1976): Untersuchungen über Salat- und Gurkenmosaikvirus in Freilandbeständen des Kopfsalates. Nachrichtenbl. Deut. Pflanzenschutzd., **28**, 106—109.
WOLF, P. (1970): Viruskrankheiten der Petersilie (*Petroselinum crispum* [Mill.] Nym.). Acta Phytopath. Hung., **5**, 95—111.
WOLF, P.—SCHMELZER, K. (1972): Untersuchungen an Viruskrankheiten der Umbelliferen. Zbl. Bakt. Abt., II. **127**, 665—672.
ZINK, F. W.—DUFFUS, J. E. (1972): Association of beet western yellows and lettuce mosaic viruses with internal rib necrosis of lettuce. Phytopathology, **62**, 1141—1144.
ZITTER, T. A.—GUZMAN, V. L. (1974): Incidence of lettuce mosaic and bidens mottle viruses in lettuce and escarole fields in Florida. Plant Dis. Rep., **58**, 1087—1091.

IMPORTANCE OF PARAMETERS OF REPRODUCTION IN DAIRY COW EVALUATION ON THE BASIS OF HUNGARIAN EXPERIMENTS

The high importance of reproductive biology in cattle breeding is well-known. The profitable reproductive capacity of the population will not only increase the number of calves, but even prosperously influence milk production.

Table 1

Comparison of production and reproductive biological

Population	Number of lactation and annual yields	Average of			
		Milk		Butterfat	
		kg	CV	kg	CV
"A"	418	6398	23	223	25
"B"	354	4331	23	206	24
Difference compared to "B"					
absolute		+2067***		+17*	
relative (%)		+ 48		+ 8	
		Average yields			
"A"	308	5982	34	213	35
"B"	231	4640	20	221	21
Difference compared to "B"					
absolute		+1342*		— 8	
relative (%)		+ 29		— 4	

* P < 5%; ** P < 1%; *** P < 0.1%.

In Hungary several authors have studied the influence of calving interval on milk and beef production. Thus, Keserü (1976) pointed out in his investigations that by increasing the calving interval from 12 to 17 months and supposing 8 years of productive life, the number of calves born will decrease from 8 to 5.6. With an average lactation performance of 4000 kg milk, the life yield of the cow will be only 22,400 kg milk instead of 32,000 kg. Bozó *et al.* (1976) stated that a decrease of 20 days in the calving interval results in a 5.7% increase in milk yield. Hámori—Lelkes (1971) found a 3.29% increase in milk production per year when the calving interval was shortened by 1 month. According to the calculations of Engel—Sándi (1977), decreasing the calving interval by 1 month results in an increase of 4.74% in the calf number. Horn *et al.* (1972) stated that a population having a lower live weight and Jersey gene-ratio, produced 9.9% more calves than a Hungarian Fleckvieh control population. When processing a large number of data from the USA Bozó—Dunay (1976) came to the conclusion that calving difficulties, as factors with a disadvantageous influence on prolificacy, are highly correlated with the body size of the cow.

In our experiments, based on practical results, it was hoped to obtain an answer to the question: how milk production will be influenced by reproductive biological parameters.

A comparison was made between the reproductive parameters and the production of two herds of different genotype-groups, kept on the same farm at the same time, under a similar management system. The average live weight of these herds was different. Significant differences also appeared in their milk yield and butterfat content. There were marked differences in their reproductive parameters, too. The first ("A") population comprised Holstein-Friesian animals, the second ("B") population consisted of a "Hungarian Dairy Brown Cattle" group, having a 50% Jersey + 50% Hungarian Fleckvieh gene-ratio, representing the 3rd—5th generations of crossbred cows.

The reproductive parameters of both herds were examined between 1971 and 1977. The service period, calving interval and number of inseminations needed for effective pregnancy were determined. Great differences appeared between the herds for these parameters, so our aim was to clarify their effects on milk production. Lactation yields of both genotype groups were checked from 1971 to 1977. Similarly, the annual milk yield and butterfat production *indices for two populations with different genotypes*

lactations I—VI							
Fat content		Calving interval		Fertility index		Service period	
%	CV	days	CV	dosage	CV	days	CV
3.47	9	440	21	3.19	90	160	76
4.78	13	375	15	2.01	75	97	58
— 1.31***		+65***		+ 1.18*		+63**	
—27		+24		+59		+65	
for years I—V							
3.57	10						
4.77	12						
— 1.20***							
—25							

were determined for the same period. The differences in reproductive traits for both genotype-groups and in the parameters of lactation and annual yields were also demonstrated. The results are given in Table 1.

With respect to the average lactation yield, the cows of population "A" produced 2000 kg (48%) more milk and 17 kg (8%) more butterfat than the individuals of population "B", but when considering the average annual milk yield this difference decreased to 1300 kg (29%) and at the same time, the cows of population "B" produced 8 kg (4%) more butterfat! This can be explained (together with the deviation in the butterfat percentage) by the fact that the individuals of group "B" were significantly superior in their reproductive traits: their calving interval was 65 days shorter, which represents a 24% difference in calf production.

The effect of the reproductive biological state of the herd on milk production is well demonstrated by considering to what extent a cow can repeat her lactation milk yield during the next year. This is shown in Table 2.

The difference between annual and lactation yields depends on:

— length of calving interval,

— date (time) of beginning of lactation, and

— difference between the current lactation result and the yield in the previous lactation.

Of these, the effect of the first factor is decisive. The second factor is negligible when calvings are continuously and uniformly distributed during the year. As far as the third point is concerned, lactation yields should increase annually (up to a certain age), in accordance with the well-known higher production potential of subsequent lactations. Table 2 demonstrates that this asserted itself well in population "B", but the worse reproductive parameters in population "A", which has higher production potential, did not lead to this regularity.

It has been proved unanimously by our data that the reproductive biological parameters must definitely be considered when evaluating the milk production of the dairy cow.

In breeding, where the prime intention is to increase productivity, it may be advantageous to use lactation yields. However, profitable production, which is primarily of interest for producing farms, is expressed much better by the annual production, since cows

Table 2

Differences in lactation and annual yields

Number of lactations and of annual yields	Population "A"			Population "B"		
	Lactation milk yield, kg	Annual milk yield		Lactation milk yield, kg	Annual milk yield	
		kg	as % of lactation		kg	as % of lactation
I	5466	5572	102	3191	3805	119
II	6028	5844	97	3951	4542	115
III	6838	6028	88	4435	4636	105
IV	7374	5824	79	4643	4934	106
V	6851	6644	96	4774	5285	111

may continue to produce after the 300 days of lactation, while the result of the succeeding years also expresses the calf production.

Our data make it clear that high genetic capacity for lactation yields is of limited value, if it cannot assert itself in annual milk yields, which are of high financial interest for a milk producing farm.

Finally it should be emphasized that it was not the intention of this paper to make a breed comparison, but only to demonstrate the high effects of reproductive parameters on milk production through practical results.

*

Prepared at the Department of Animal Husbandry, University of Veterinary Sciences, Budapest; Agricultural College, Kaposvár; Research Institute for Animal Production, Herceghalom.

I. Bodó, J. Dohy, A. Dunay, L. Jávorka

References

Bozó, S.—Dunay, A. (1976): A tej koncentráció és a testnagyság hatása a tejelő marha típusára és termékelőállítására (Effect of milk concentration and body size on the type of dairy cattle and production). Állattenyésztés, **25,** 435—448.

Bozó, S.—Dunay, A.—Rada, K.—Kovács, J. (1976): Néhány tenyésztési módszer, illetve paraméter megváltoztatásának hatása a szarvasmarha tej- és hústermelésére, továbbá a létszám alakulására (The effect of modifying several breeding methods and parameters on milk and meat production and population in cattle breeding). Állattenyésztés, **25,** 317—325.

Engel, Gy.—Sándi, O. (1977): A hatékonyság elemzése az állattenyésztésben (Analysis of efficiency in animal breeding). Magyar Mezőgazdaság, **32/41,** 16—17.

Hámori, D.—Lelkes, B. (1971): A meddőség és a tőgygyulladás okozta selejtezések gazdasági hatásai Magyarországon (Economical effects of cullings due to infertility and mastitis in Hungary). Magyar Állatorvosok Lapja, **26,** 397—400.

Horn, A.—Bozó, S.—Dohy, J.—Dunay, A. (1972): A "tejelő magyar barna" fajtakonstrukció (Breed construction of "Hungarian Dairy Brown" cattle). ÁKI Közlemények, Herceghalom, 1—81.

Keserü, J. (1976): Gondolatok az V. ötéves terv mezőgazdasági feladatainak teljesítéséhez, különös tekintettel az állattenyésztésre (Reflections on the fulfilment of agricultural goals in the 5th Five Year Plan with special regard to animal husbandry). Állattenyésztés, **25,** 385—401.

THE ROLE OF TITANIUM IN PLANT LIFE II. FOLIAR NUTRITION OF ALFALFA WITH TITANIUM SOLUTION

Besides the use of traditional fertilizers the application of various spray fertilizers is becoming more and more wide-spread in agricultural practice. In addition to macrocomponents they mostly contain those microelements (B, Cu, Mn, Zn, Mo) which, according to our present knowledge, play an important role in the biochemical processes of plants. On the basis of several years of experiments carried out with leaf sprays titanium can be included in the category of useful microelements.

In previous publications a considerable increase has been reported in the chlorophyll content of the leaves of experimental plants and a parallel increase in the sugar contents of grape, apple, tomato and sugar-beet in response to foliar nutrition with titanium solution (PAIS 1974, FEHÉR 1975, PAIS *et al.* 1977).

The results of our investigations suggest that titanium as a microelement has a wide range of action which is not confined to certain plant species. Considering that a search is being made all over the world for further ways to increase protein production, foliar titanium nutrition was applied to alfalfa, which belongs to the fodder plant species supplying the largest amounts of protein.

In co-operation with the Department of Agronomy of the Horticultural University small plot experiments were set up on the Soroksár trial grounds of the university in the years 1976 and 1977. Foliage spraying was applied to the alfalfa variety Nagyszénási planted in 1975. The 15 m^2 plots, arranged in a split-plot design with six replications, were sprayed twice with a hand sprayer before each cutting.

The solution used for foliar nutrition contained titanium in the form of a chelate-complex (PAIS—FEHÉR 1975). Alongside the control plots two treatments, one with a lower and the other with a higher concentration of active agent, were set up. In the tables treatment 1 represents 1 g Ti/ha, and treatment 2 means that 5 g Ti/ha were contained in the spray fertilizer applied; each plot was sprayed with 3 litres of solution at the concentration required. The licensed spray contains titanium chelate only; the effect of the chelate-forming compound was controlled in a separate experiment.

The soil of the experimental area was sand from the region between the rivers Danube and Tisza; the pre-plantation data are presented in Table 1. The basic pre-plantation fertilization consisted of 75 kg/ha N, 94 kg/ha P_2O_5 and 120 kg/ha K_2O.

Table 1

Soil analysis data for the experimental area

pH	Humus, %	N	P_2O_5	K_2O	Salt, %
		mg/100 g soil			
6.9	1.9	1.85	78.0	32.0	0.02

The first experiment, carried out in 1976, was a pilot study: spraying was carried out on two occasions and the quantity of the green crop, the protein contents of the samples and the catalase enzyme activity in the leaves were measured. Since positive results were obtained the experimental series was continued in 1977; the results of the latter are presented in this publication.

Dates of operations: first spraying: 21st and 28th April; first cutting: 11th May; second spraying: 26th May and 3rd June; second cutting 16th June; third spraying: 27th June and 4th July; third cutting: 11th July.

Table 2

Fresh yield of alfalfa per cutting and in total after foliar nutrition, 1977

Data of samples	Fresh yield			
	kg/plot	q/ha	%	
1st cutting				
Control	23.66	157.77	100.0	$SD_{5\%} = 1.248$
Treatment 1	24.81	165.44	104.8	$F_{value} = 6.16$
Treatment 2	25.65	171.00	108.3	
2nd cutting				
Control	15.62	104.16	100.0	$SD_{5\%} = 0.388$
Treatment 1	16.36	109.08	104.7	$F_{value} = 19.06^{*}$
Treatment 2	16.67	111.14	106.7	
3rd cutting				
Control	17.60	117.33	100.0	$SD_{5\%} = 0.635$
Treatment 1	18.56	123.77	105.4	$F_{value} = 5.75$
Treatment 2	18.15	121.05	103.1	
Total:				
Control	56.25	379.26	100.0	$SD_{5\%} = 1.306$
Treatment 1	59.70	398.29	105.4	$F_{value} = 29.41^{*}$
Treatment 2	60.48	403.20	106.3	

* Significant at $P < 0.1\%$.

Yield trend: The data in Table 2 show that if the summarized results of the three cuttings are taken into consideration both treatments resulted in a significant increase in the quantity of green crop compared to the control. The lower concentration of leaf-spray caused a more uniform yield increase: each of the three cuttings gave approximately the same amount of surplus yield compared to the control. In the case of the higher concentration the greatest yield difference was obtained with the first cutting. With regards to the total yield there was no essential difference between the two treatments.

1. Analysis of components. The protein content of the alfalfa samples was determined with the spectrophotometric method elaborated by Lowry *et al.* (1951). Extinction was registered at 750 nm with a "Spekol UV-VIS" spectrophotometer. The results of the examinations are summed up in Table 3. As seen from the table, in treatment 1 the amount of protein increased in the samples from all three cuttings. However, the higher titanium concentration caused an extraordinary increase in protein content in the first phase of the vegetation period, while in the samples from the second and third cuttings some inhibition was observed.

2. The carotene content was determined according to the standard MÉM 384-71-S.19. The results are shown in Table 4. As a response to foliar nutrition the carotene content in the alfalfa leaves greatly increased; the higher titanium concentration was found to be more efficient. The F-test pointed out a difference significant at the $P = 5\%$ level between the treatments of the first and second cuttings, while the amount of carotene found in the leaves after the third cutting indicated no significant difference between the treatments.

Table 3

Protein content in alfalfa samples after foliar nutrition

Data of samples	Crude protein in air-dry matter, g/kg	%
1st cutting		
Control	216	100.0
Treatment 1	234	108.3
Treatment 2	366	169.4
2nd cutting		
Control	187	100.0
Treatment 1	231	123.5
Treatment 2	183	97.9
3rd cutting		
Control	212	100.0
Treatment 1	216	101.9
Treatment 2	200	94.3

Table 4

Carotene content in alfalfa samples after foliar nutrition

Data of samples	Carotene content as β-carotene, mg/kg	%	
1st cutting			
Control	69.16	100.00	$SD_{5\%} = 29.66$
Treatment 1	100.00	144.59	$F_{value} = 6.2$
Treatment 2	115.00	166.28	
2nd cutting			
Control	53.33	100.00	$SD_{5\%} = 32.78$
Treatment 1	86.66	162.49	$F_{value} = 5.15$
Treatment 2	99.16	185.93	
3rd cutting			
Control	110.83	100.00	$SD_{5\%} = 10.16$
Treatment 1	101.66	91.72	$F_{value} = 1.34$
Treatment 2	118.33	106.76	

3. In the alfalfa samples the titanium was determined by spectrophotometry according to the method described earlier (FEHÉR 1975, PAIS *et al.* 1975). Titanium can also be detected in the stalks of alfalfa, but both in the control and the treated samples the leaves contained far more titanium, about twice or two and a half times as much. No significant difference could be pointed out between the samples from the various treatments, as might be expected, since the spray contained a very low concentration of titanium. On the basis of Table 5 it can be calculated that on an area of 1 ha the plants contain 400—500 g titanium. This microelement quantity is not excessively high compared to the data of TONKONOZHENKO—KHLYUPINA (1974), who determined the titanium content in several plant species in the Krasnodar area and found the largest quantities, as high as 2700 g/ha titanium, in alfalfa. The results obtained by these authors can probably be explained by the presence of a relatively high titanium content in the soil.

Table 5

Determination of titanium in alfalfa samples

Data of samples	Titanium content in dry matter, ppm	
	leaf	stalk
1st cutting		
Control	56.4	19.4
Treatment 1	61.8	33.7
Treatment 2	59.2	37.8
2nd cutting		
Control	50.9	20.8
Treatment 1	58.6	33.8
Treatment 2	63.0	34.6
3rd cutting		
Control	53.2	21.4
Treatment 1	62.0	33.7
Treatment 2	60.5	30.8

4. While studying the mechanism of the biological action of titanium on plants the activities of various kinds of enzymes were measured. The fact that the amount of chlorophyll in the leaves is increased by leaf spraying suggests that this procedure has a favourable influence on the photosynthetic processes. In leaves of vine and sugar-beet treated with titanium both DOBROLYUBSKY (1962) and RUTSKAYA (1971) observed an increase in the catalase activity. Similar results were obtained on examining alfalfa leaves.

FRENYÓ's (1961) method was used to measure the enzyme activity. The fresh leaf samples, taken after cutting, were thoroughly washed, and rinsed first with distilled and then with ion-free water. Ten leaf discs each 3 mm in diameter were used for each measurement. This amount of material proved sufficient to register the oxygen produced in Frenyó's glass tube capillary. The volume of oxygen gas released in one minute depends on the activity of the catalase enzyme. Table 6 contains the average results of the measurements.

*

Table 6

The activity of the catalase enzyme in sprayed alfalfa leaves

Data of samples	O_2, mm³/minute	
1st cutting		
Control	438.00	$SD_{5\%} = 26.13$
Treatment 1	486.67	$F_{value} = 140.28^*$
Treatment 2	626.57	
2nd cutting		
Control	421.22	$SD_{5\%} = 38.81$
Treatment 1	500.42	$F_{value} = 81.55^*$
Treatment 2	640.68	
3rd cutting		
Control	395.07	$SD_{5\%} = 57.44$
Treatment 1	639.29	$F_{value} = 45.86^*$
Treatment 2	547.95	

* Significant at $P < 0.1\%$.

Prepared at the University of Horticulture, Department of Chemistry and Department of Agronomy.

M. Fehér, K. Kádár, Z. Szabó, G. Gombkötő, O. Lohonyai, I. Pais

References

Dobrolyubsky, O. K. (1961): The effect of titanium as a trace element on some biochemical processes in grapes. Tr. II. Mezhvuz. Soveshch. po Mikroelem. 156—162.

Fehér, M. (1975): A titán jelentősége a kertészeti növények tápanyagforgalmában (Role of titanium in the nutrient turnover of horticultural plants). Doctor's dissertation, University of Horticulture, 89.

Frenyó, V. (1961): Eljárás és eszköz gázképződéssel járó folyamatok vizsgálatára (Technique and instrument for the study of processes involving gas formation). Patent description. OTH. 150. 379; F.S.-542.

Lowry, O. H.—Rosebrough, N. J.—Farr, A. L.—Randall, R. J. (1951): Protein measurement with the Folin phenol reagent. J. Biol. Chem., **193,** 265—275.

Pais, I. (1974): Objektív kémiai vizsgálatok néhány tápelem szerepének felderítésére kertészeti növényekben (Objective chemical experiments to clarify the role of some nutritive elements in horticultural plants). Doctor's dissertation, Hungarian Academy of Sciences, 183.

Pais, I.—Fehér, M. (1975): Mikroelemet tartalmazó permetezőszer kertészeti és mezőgazdasági növények termésében a beltartalmi értékek, elsősorban a cukor-tartalom növelésére (A spray containing microelements to increase the value of components, primarily the sugar content, in the fruits of horticultural and agricultural crops). Patent description. OTH. A 01 N 5/00

Pais, I.—Fehér, M.—Cornides, I. (1975): A titán(IV) meghatározása növényi mintákban (Determination of titanium-(IV) in plant samples). Kert. Egyet. Közl., **XXXIX,** 213—217.

Pais, I.—Fehér, M.—Farkas, E.—Szabó, Z.—Cornides, I. (1977): Titanium as a new trace element. Comm. Soil Sci. Plant Anal., **8/5,** 407—410.

RUTSKAYA, S. I.—РУТСКАЯ. С. И. (1971): Титан. его влияние, на физиологические процессы и продуктивность захардой свеклы. В.: Значение новых форм минеральных удобрений в увеличении производства сахарной свеклы. Киев. 254—266.
TONKONOZHENKO, E. V.—KHLYUPINA, M. I. (1974): Titanium in soils and plants of the Krasnodar Territory. Pochvoved., **3**, 38—45.

THE EFFECT OF TEMPERATURE ON GROWTH HABIT IN HOMOEOLOGOUS GROUP 5 OF TRITICUM AESTIVUM

The method of aneuploid analysis has been used for studying the genetics of growth habit in common wheat for nearly a quarter of a century (UNRAU 1950, SEARS 1953, KUSPIRA—UNRAU 1957, KNOTT 1959, MORRISON 1960, TSUNEWAKI—JENKINS 1961, TSUNEWAKI 1966, HALLORAN—BOYDELL 1967, RAJKI—RAJKI 1969, LAW 1971, 1972, LAW—WORLAND 1973). It is unanimously agreed, that the chromosomes of homoeologous group 5 are essentially responsible for spring versus winter habit.

This paper reports on the effect of different temperature treatments on the growth habit of monosomics for homoeologous group 5 of Chinese Spring (CS), and the F_1 monosomics produced by crossing these with the winter wheat varieties Rannyaya 12 (Ran 12) and Mironovskaya 808 (Mir 808).

The materials used in this experiment were CS 5A, 5B and 5D monosomics and disomics, together with the F_1 hybrids formed by crossing them with Ran 12 and Mir 808. In the crosses, which were carried out in the nursery, the female parents were CS monosomic and disomic lines, the seed samples of which had been obtained from the Plant Breeding Institute, Cambridge in 1966. The vernalisation requirement of the winter variety Ran 12 is fairly short, whereas that of Mir 808 is long.

The chromosome number of the parents and the F_1 hybrids was determined from root-tip mitosis, and was checked at first metaphase meiosis. Spike morphology also helped to distinguish monosomics.

Seed germination and the pretreatment of the seedlings were carried out in a phytotron chamber, with an 8-hour night temperature of 5°C and a 16-hour day temperature of 10°C. After the 14-day pretreatment, the seedlings were transferred to three phytotron chambers maintained at different temperatures. The night/day temperatures in the three chambers were 5°/10°C, 10°/15°C and 15°/20°C respectively. In all three chambers the daylength was 16 hours, the illumination intensity 10,000 lux, and the relative humidity 65% by day and 80% at night.

The pots were distributed at random in the chambers. For each treatment 5 plants were available. The number of days required for shooting and heading served as a criterion of growth habit. The day on which the growth rate changed from linear to logistic was taken as the shooting date. The day on which approximately half the spike had emerged from the covering leaves was recorded as the heading date. Two-factor analysis of variance was used to evaluate the data collected (SVÁB 1973).

After the 14 day pretreatment at 5—10°C, under artificial conditions, the CS plants headed completely at all temperatures, while at 15—20°C 50% of the Ran 12 plants and 60% of the Mir 808 plants failed to head (Table 1). The number of days required for heading in CS and F_1 disomics increased as the temperature fell. CS 5A and 5D monosomics at 5—10°C and 15—20°C, and F_1 5A and 5D monosomics at all temperatures deviated significantly from the disomics. This difference was greatest at 15—20°C. In the F_1 generation, the 5D monosomics headed later than the 5A at all temperatures; the 5B monosomics did not differ significantly from the corresponding disomics.

Table 1

The effect of temperature on the number of days required for heading in homoeologous group 5

	Temperature (°C)	Monosomic lines	Days required for heading		
			CS	F_1 CS × Ran 12	F_1 CS × Mir 808
14 days pretreatment at 5—10	5—10	5A	+ 6.8***	+13.8***	+18.0***
		5B	+ 1.6	+ 2.2	— 2.4
		5D	+ 4.0*	+24.2***	+23.4***
		Disomics	110.2	121.2	129.4
		♂		141.5	181.2
	10—15	5A	+ 3.2	+11.4***	+15.2***
		5B	— 3.0	— 2.2	+ 1.6
		5D	+ 2.8	+20.8	+25.6***
		Disomics	88.4	97.0	99.6
		♂		131.6	174.8
	15—20	5A	+11.6***	+13.2***	+23.0***
		5B	+ 1.2	+ 5.4*	— 1.2
		5D	+14.0***	+42.2***	+39.4***
		Disomics	74.4	87.0	96.8
		♂		124.5+	178.5++

(+) later or (—) earlier heading of monosomics as compared to the corresponding disomics.
* $P < 0.05$ + = 50% of plants not headed
*** $P < 0.001$ ++ = 60% of plants not headed

Table 1 also demonstrates that the number of days required for heading in the F_1 disomic hybrids CS × Ran 12 and CS × Mir 808 were closer to the corresponding data for CS than to those of the winter varieties, but dominance could not be considered as complete.

The number of days required for shooting was calculated as a percentage of that required for heading (Table 2). The data indicate that for the CS disomic this ratio remained constant at 5—10°C and 10—15°C, but increased at 15—20°C. In the case of both the F_1 disomics and the winter varieties this value increased with the rise in temperature. On comparing the F_1 monosomics, the lowest value was found for 5B and the highest for 5D.

Thus the number of days required for shooting and heading is influenced by both the genotype and the temperature. Nor can the interaction of these two factors be ignored, since it gave rise to a mean square deviation, significant on the basis of the F-test.

*

Prepared at the Agricultural Research Institute of the Hungarian Academy of Sciences, Martonvásár.

J. Sutka, E. Rajki

Table 2

The effect of temperature on the relationship between days for shooting and days for heading (%)

	Temperature (°C)	Monosomic lines	CS	F_1 CS × Ran 12	F_1 CS × Mir 808
14 days pretreatment at 5—10	5—10	5A	56.9	65.9	63.8
		5B	56.7	58.5	57.9
		5D	58.3	65.1	65.6
		Disomics	57.9	58.4	62.3
		♂		53.0	64.6
	10—15	5A	63.5	67.9	70.2
		5B	61.6	65.8	70.0
		5D	66.9	69.6	71.1
		Disomics	57.9	68.7	69.7
				65.3	70.9
	15—20	5A	70.9	76.3	78.5
		5B	62.2	69.1	77.0
		5D	70.6	78.6	83.0
		Disomics	65.0	73.3	76.0
		♂		71.5	77.3

References

Halloran, G. M.—Boydell, C. W. (1967): Wheat chromosomes with genes for vernalisation response. Can. J. Genet. Cytol., **9**, 632—639.

Knott, D. R. (1959): The inheritance of rust resistance. IV. Monosomic analysis of rust resistance and some other characters in six varieties of wheat including Gabo and Kenya Farmer. Can. J. Plant Sci., **39**, 215—228.

Kuspira, J.—Unrau, J. (1957): Genetic analysis of certain characters in wheat using whole chromosome substitution lines. Can. J. Plant Sci., **37**, 300—326.

Law, C. N. (1971): Rep. Plant Breed. Inst., Cambridge, England, 1970, 88—89.

Law, C. N. (1972): The analysis of intervarietal chromosome substitutions in wheat and their first generation hybrids. Heredity, **28**, 169—179.

Law, C. N.—Worland, A. J. (1973): Chromosome substitutions and their use in the analysis and prediction of wheat varietal performance. Proc. 4th Int. Wheat Genet. Symp., Columbia, USA.

Morrison, J. W. (1960): The monosomic analysis of growth habit in winter wheat. Z. Vererbungslehre, **91**, 141—151.

Rajki, E.—Rajki, S. (1969): Monosomic analysis of growth habit in autumnization process. Fifth Congress of the Eucarpia, Milan, 1968. Genetica Agraria, 43—47.

Sears, E. R. (1953): Nullisomic analysis in common wheat. Amer. Nat., **87**, 245—252.

Sváb, J. (1973): Biometriai módszerek a kutatásban (Biometric research methods). Mezőgazdasági Kiadó, Budapest, 517.

Tsunewaki, K. (1966): Comparative gene analysis of common wheat and its ancestral species. II. Waxiness, growth habit and awnedness. Jap. J. Bot., **19**, 175—229.

Tsunewaki, K.—Jenkins, B. C. (1961): Monosomic and conventional gene analysis in common wheat. II. Growth habit and awnedness. Jap. J. Genet., **36**, 428—443.

Unrau, J. (1950): The use of monosomes and nullisomes in cytogenetical studies of common wheat. Sci. Agric., **30**, 66—89.

COMPARATIVE MORPHOLOGICAL AND PHENOLOGICAL STUDY ON PLUM VARIETIES

The genus *Prunus* includes a large number of species and varieties which are important from the point of view of fruit growing. The ancestor of the cultivated plum varieties is still unknown, so it is particularly difficult to discover how they are related to each other. In the classical experiments of RYBIN (1936) *P. spinosa* L. and *P. cerasifera* Ehrh. were found to be easily hybridized, especially when *P. spinosa* was the mother plant. According to recent data, however, *P. spinosa* L. cannot be a component in the development of *P. domestica* L., except perhaps in a few cases (SALESSES 1967, 1970, 1973, 1975). The chromosome conditions of *Prunus* species have been studied by a number of authors and the results confirm Rybin's theory (CRANE—LAWRENCE 1952, HASKELL—DOW 1955, MORRISON 1964).

In clearing up the unsettled questions considerable help may be offered by the investiga- and systemisation of the currently cultivated and observed plum varieties as an augmentation of genetic and crossing experiments. Apart from its positive botanical usefulnes the work also enables a complex evaluation of the varieties to be made.

Flower organization studies have been carried out at Cegléd since 1968. In the major genera of the subfamily *Prunoideae* a numerical relationship has been found between the gynoecium and the androecium, namely, there is a negative correlation between pistil length and stamen number (SURÁNYI 1970, 1974, 1976). In the genus *Prunus*, in particular, the correlation may be connected with the fertility conditions of the individual species, varieties or clones.

The systemization, pomological description and phenological characterization of plum varieties have been the subject of research for a long time. The number of varieties which have been dealt with is very high. DAHL (1935) published important data on the flower structure of plum varieties, while RÖDER (1940) proceeded to systemize the varieties; some of his methods were applied in the experiments described in the present paper, together with information published by RÉMY (1954) and TÓTH (1957).

The phenological characterization of the plum varieties in Hungary was started by TÓTH (1957) and BRÓZIK (1960). Tóth examined the full range of varieties, while Brózik only dealt with the most important farm and garden varieties. VONDRÁČEK (1975) studied the pomologically important phenophases of some 100 varieties and tried to find the major correlations between the individual phenophases. Thus, he found correlations between leaf-bud opening and flowering, leaf-bud opening and fruit ripening, and between flowering and fruit ripening; the correlations were most significant for the group of true plums.

Our interest was aroused by these complex studies because no satisfactory explanation had yet been found for the morphological differences between flowers (SURÁNYI 1978). Therefore it seemed expedient to systemize the varieties from a botanical point of view (RÖDER 1940, TERPÓ 1974) rather than making an empirical classification (TÓTH 1975, SURÁNYI 1978).

In the present paper only half of our investigations (which included 70 varieties) are described; those presented here are characteristic and important varieties with fixed taxonomic places.

The plum variety collection was established at Cegléd in 1954—1955. Starting in 1963, 38 varieties have been examined for the major phenophases. The phenophases examined are: leaf-bud opening, beginning of flowering, end of shoot growth, beginning of fruit colouring and ripening, beginning of discolouration of leaves and defoliation. Trunk growth, crown diameter, crown height and shoot growth at the four cardinal points were measured every year (from 1960 onwards). Each variety was represented by 5 trees; the rootstock was cv. Myrobalan. The data of the 5 trees per variety were averaged and the characteristic data of the trees, i.e. the phenophases, were processed using analysis of variance with 8 replications. The phenophases are given as the number of days from 1st January.

In 1970 informative surveys were made concerning the vegetative, and in part the generative organs. On 10—12th July twenty shoots of each variety were collected, and the 6th and 7th leaves (from the base) were measured for length, width and length of petiole. In the same year 10 fruits per variety were weighed singly, as were their putamens.

The putamen index was determined by the method of Lösching—Passecker (1954) using the formula $L^2/W \cdot T$, where L is the length of the putamen, W its width, and T its thickness. The fruit yield was evaluated in the same way as the phenophases of the varieties, that is, the crop years represented the replications. The alternate bearing index was calculated according to Schumacher (1965).

$$\text{BBI-value} = \frac{\text{Yield difference of two successive years}}{\text{Joint yield of two successive years}} \times 100$$

Pistil length, stamen number and relative stamen number (i.e. the number of stamina per plant divided by the length of pistil) were obtained in each year from 1975 to 1977 from 30 flowers per variety; the results presented here are the averages of the three years. The petals were only measured in 1975, while pollen germination and filament survey were carried out in 1977. Pollen was obtained when the anthers dehisced. Approximately 80—150 pollen grains were germinated on three occasions in a 10% saccharose solution. The suspension was incubated for 24 hours in steam-saturated glass tubs.

First the taxa were compared, then the individual self-fertility groups were examined from the same points of view. The comparison of the 12 self-fertile (S.F.), 6 semi-self-fertile (S.S.F.), 5 practically self-sterile (P.S.S.) and 15 self-sterile (S.S.) plum varieties required analysis of variance with a varying number of replications.

For the most important factors correlation calculations were made, first using the averages of the taxa, then the full range of data; in the paper only the latter are published.

The groups formed on the basis of publications by Röder (1940) and Terpó (1974) are presented below; the individual species and groups of varieties were represented by the following cultivars:

1. *Prunus cerasifera* Ehrh.:
   Alutsche (S.S.);
2. *P. insititia* Jusl.:
   Bódi (S.F.);
3. *P. domestica* L. convar. *hungarica* (L.) Terpó:
   a) Besztercei plum clones: II.b 28/5 (S.S.F.), III.b 15/5 (S.S.F.), IV.a 1/4 (P.S.S.), IV.b 25/1 (S.F.) and Besztercei muscat (S.F.);
   b) Foreign varieties: Italian Prune (S.F.), Bühler Frühzwetsche (S.F.), Borsumer (S.F.), Tragedia (S.S.), Belle de Louvain (S.S.F.);
4. *P. domestica* L. convar. *subrotunda* (L.) Terpó:
   Kirke (S.S.), Ontario (S.F.), Gelbe Aprikosenpflaume (S.S.), Gelbe Herrenpflaume (S.S.), Bunter Perdrigon (S.F.);
5. *P. italica* Borkh. em. Kárpáti convar. *pomariorum* Boutigny:
   Catalan (S.S.);
6. *P. italica* Borkh. em. Kárpáti convar. *claudiana* Poir.:
   Althann (P.S.S.), Green Gage (P.S.S.), Angoulème (S.F.), Jodoigne (S.S.), Prince red (S.S.);
7. *P. italica* Borkh. em. Kárpáti convar. *ovoidea* Mart.:
   Red eggplum (S.S.F.), Blue eggplum (S.S.), Yellow eggplum (S.S.), Grand Duke (P.S.S.), Angelina Burdett (S.S.);

Table 1

Important characteristics of trees in the plum taxa examined

Species, convarietas	Girth, cm (1960)	Index 1970/1960	Diameter of crown, cm (1970)	Height of crown, cm (1970)	Crown quotient (1970)
P. cerasifera cv. Alutscha	32.4	204	657	415	1.58
P. insititia cv. Bódi	37.2	229	587	402	1.46
P. domestica					
convar. hungarica	25.0	222	607	439	1.38
foreign varieties	25.8	225	591	432	1.38
convar. subrotunda	28.4	193	582	374	1.42
P. italica convar. *pomariorum*					
cv. Catalan	18.7	223	414	425	0.97
convar. *claudiana*	29.5	213	632	457	1.42
convar. *ovoidea*	26.4	194	543	366	1.50
convar. *mamillaris*	22.9	240	556	474	1.20
P. syriaca convar. *cerea*	22.9	216	534	373	1.45
F-test	5.11**	5.88***	9.26***	5.16**	3.57*
L.S.D. 5%	3.25	20.1	35.7	42.9	0.14

* P = 5%
** P = 1%
*** P = 0.1%

8. *P. italica* Borkh. em. Kárpáti convar. *mamillaris* Schübl. et Mart.:
Sainte Catherine (P.S.S.), Giant (S.F.), Blue date (S.S.), Green date (S.S.), Gömöri nyakas (S.S.F.);
9. *P. syriaca* Borkh. em. Kárpáti convar. *cerea* L. em. Kárpáti:
Yellow mirabelle (S.F.), Nancymirabella (S.S.F.), Metzer Mirabelle (S.S.), Septembrische Mirabelle (S.F.), Königinsmirabelle (S.S.).

At the age of 5 years (in 1960) the growth of the trunk diameter showed obvious differences; by 1970 the backwardness compared to *P. cerasifera* was lessened in the varieties of several convarietates. Cv. Bódi, the foreign varieties, cv. Catalan and the eggplums began to produce considerable amounts of yield during that period.

The largest crowns, as regards both diameter and height, are formed by the cv. Alutscha, the Besztercei group and the greengages. The quotient obtained when the crown diameter is divided by the crown height characterizes the habit of the tree. The cv. Catalan forms a spread crown, while the shoot systems of cv. Alutscha and of the eggplums and mirabelles tend upwards (Table 1).

In the period examined (1963—1970) cv. Alutscha excelled in the rate of shoot growth and average length of internode. Cv. Catalan and the mirabelles were also found to have long internodes.

The leaves are very short in cv. Bódi and cv. Catalan, while the width of leaf is the smallest in cv. Bódi. The leaf index was found to be a specific character; the *insititia*-type cv. Bódi has longish leaves, while those of the cv. Catalan are round. The length of petiole also

Table 2

Important characteristics of shoots in the plum taxa examined (1970)

Species, convarietas	Yearly shoot growth (1963–70), cm	Internode length, cm	Length of leaves, mm	Width of leaves, mm	Leaf index	Length of petiole, mm
P. cerasifera cv. Alutscha	26.7	2.05	76	47	1.62	19
P. insititia cv. Bódi	16.2	1.79	59	27	2.18	13
P. domestica						
convar. *hungarica*	15.4	1.61	79	39	1.97	14
foreign *varieties*	16.9	1.80	88	46	1.94	20
convar. *subrotunda*	17.6	1.61	87	50	1.74	22
P. italica convar. *pomariorum*						
cv. Catalan	15.0	1.97	53	41	1.29	13
convar. *claudiana*	16.3	1.78	90	47	1.91	19
convar. *ovoidea*	17.6	1.61	81	42	1.90	21
convar. *mamillaris*	18.7	1.61	76	43	1.80	21
P. syriaca convar. *cerea*	16.8	1.98	71	41	1.71	14
F-test	4.12**	4.31**	16.42***	3.86**	3.40*	58.10***
L.S.D. 5%	1.55	0.19	6.4	5.4	0.16	2.2

* P = 5%
** P = 1%
*** P = 0.1%

showed characteristic differences between the taxa; there are groups of varieties with short (cv. Bódi and cv. Catalan, *hungarica*), medium (cv. Alutscha, *claudiana*, *domestica* varieties of foreign origin) and long (*ovoidea*, *mamillaris*, *subrotunda* convarieties) petioles, respectively (Table 2).

Over a 7-year average the greengages, domestic plums and some eggplums produced the largest yields; low productivity was due to fertility disorders in cv. Alutscha and the mirabelles, and to the small fruit weight in cv. Bódi. The putamen index is the lowest in plums with round and oval fruits; the oblong shape of fruit is coupled with a high putamen index. The putamen index, which is also suitable for the differentiation of the varieties, shows great variation from one variety to the other. Our opinion, based on experience, that yield volume and average fruit weight are in negative correlation could not be experimentally proved. This is just as characteristic a feature of the taxa as the extent of the tendency to periodicity. The *Prunus* species and varieties gave high BBI values, as the alternation well exceeded 15% (Table 3).

The pistil length of plums ranges from 9 to 15 mm. The number of stamina shows a wider amplitude, varying between 18 and 30. The relative stamen number may be either low or high in *P. domestica*, *P. italica*, *P. syriaca* and *P. insititia*, and even some convars of the domestic and damson plums are not the same on the basis of flower morphology. The

Table 3

Characterization of fruit in the plum taxa examined (1970)

Species, convarietas	Yield, kg/tree	BBI-value	Weight of fruit, g	Putamen index, $L^2/W.T.$
P. cerasifera cv. Alutscha	25.6	41	40.0	3.05
P. insititia cv. Bódi	34.3	40	9.0	4.74
P. domestica				
convar. *hungarica*	60.6	43	16.6	5.66
foreign varieties	60.1	28	24.6	4.78
convar. *subrotunda*	44.8	45	27.4	2.65
P. italica convar. *pomariorum*				
cv. Catalan	24.3	68	8.0	3.68
convar. *claudiana*	72.9	45	33.0	2.87
convar. *ovoidea*	49.2	38	29.6	4.39
convar. *mamillaris*	30.8	37	27.8	8.07
P. syriaca convar. *cerea*	28.1	42	11.2	2.77
F-test	11.47***	4.28**	20.05***	19.23***
L.S.D. 5%	14.1	8.4	5.0	1.31

** P = 1%
*** P = 0.1%

pollen germination of the taxa is generally good. Cv. Alutscha proved to be female sterile, but its potential productivity is not high either.

The length and width of the petals and the size of the filaments in the inner and outer circle are also different. In cv. Alutscha and cv. Bódi the anthers are carried on very short filaments; the *hungarica* plums, on the other hand, have very long filaments. The filament is the shortest in the mirabelles. These characters are also suitable for making distinctions between the plums (Table 4).

The dates of vegetative and reproductive phenophases show great fluctuations. In cv. Bódi leaf-bud opening hardly precedes the beginning of flowering but the period of shoot growth is completed at about the average time (on 29th June). Cv. Alutscha begins to blossom early, and the other phenophases also precede the major phenophases of other plums. Interesting exceptions were found again when studying the colouration and ripening of fruit. In the case of cv. Bódi, round plums (*subrotunda*) and date-plums 7—12 days elapse from the colouration to the ripening of fruit, while in the Besztercei group the fruit ripens in 44 days. The varieties belonging to the species *P. domestica* are the latest of all as regards the discolouration and abscission of the leaves. The vegetation period is very short (219—220 days) in cv. Catalan and cv. Alutscha, and very long (229—230 days) in cv. Bódi and in the case of eggplums. The period of intensive shoot growth (from leaf-bud opening to the end of shoot growth) is the longest in species and varieties producing the largest amounts of fruit (greengages, domestic plums and some eggplums) (Table 5).

Table 4

Morphological characteristics of flowers in the plum taxa examined (1975–1977)

Species, convarietas	Pistil length, mm	Stamen number, pc	SN/PL, pn/mm	Pollen germination, %	Length (of petal, mm)	Width (of petal, mm)	Length of filament internal (mm)	Length of filament external (mm)
P. cerasifera cv. Akutscha	9.1	28.2	3.02	0	10.0	8.0	4.0	6.0
P. insititia cv. Bódi	9.2	22.0	2.33	61	11.0	9.0	4.0	6.0
P. domestica convar. *hungarica*	14.0	18.1	1.29	50	12.4	8.6	6.6	9.4
foreign varieties	13.5	25.5	1.87	42	12.2	8.2	6.0	8.4
convar. *subrotunda*	11.3	27.3	2.43	58	12.0	10.0	5.0	7.0
P. italica convar. *pomariorum* cv. Catalan	10.1	20.7	2.08	63	12.0	7.0	6.0	8.0
convar. *claudiana*	11.9	26.4	2.47	45	11.6	9.4	4.8	7.8
convar. *ovoidea*	11.7	27.6	2.39	34	12.6	9.8	5.8	8.0
convar. *mamillaris*	14.3	28.3	2.02	67	11.4	8.8	6.6	8.4
P. syriaca convar. *cerea*	10.4	27.9	2.67	49	9.2	6.8	4.8	7.0
F-test	13.51***	48.63***	13.87***	14.03***	16.01***	1.62	3.76**	8.78***
L.S.D. 5%	0.80	1.48	0.16	6.8	0.84	2.50	1.20	0.82

** P = 1%
*** P = 0.1%

Several papers were published earlier on the flowering biology of plums. The varieties were then only compared by self-fertility groups. This is now complemented with a taxonomic consideration of the varieties.

All our observations are summarized in Table 6. The table reveals that semi-self-fertile, practically self-sterile and self-sterile plum varieties generally have higher vegetative capacities than self-fertile varieties. On the basis of the size of leaf-blade and length of petiole great differences can be observed. It is particularly interesting to compare the vegetative and reproductive capacities, since specific fruit formation (relative to the crown size) is the lowest in partly self-fertile and completely self-sterile varieties.

There are significant differences in the major phenophases as well. The 6 semi-self-fertile varieties were the last to ripen, while the period of vegetation was the longest in the practically self-sterile group. The average length of the period of dormancy was 135–140 days when considered either according to varieties or fertility groups, this is why the *cerasifera*-type cv. Alutscha remains dormant for the shortest time. The relative succession of the phenophases (in the individual varieties, variety groups and species) exhibits a strict regularity: the exceptions are indicative of fertility disorders.

The pistil length, stamen number, relative stamen number and pollen germination percentage fluctuate consistently, which confirms the conclusions drawn from our earlier

Table 5

Important phenophases of plum taxa (on the basis of the days elapsed from 1st January) (1963—1970)

Species, convarietas	Leafbud opening	Beginning of flowering	End of sprouting	Beginning of fru.t		Beginning of leaf	
				colouration	ripening	discolouration	abscission
P. cerasifera cv. Alutscha	91	100	164	196	210	252	273
P. insititia cv. Bódi	89	101	180	191	198	269	280
P. domestica							
convar. *hungarica*	95	107	187	202	246	280	286
foreign varieties	92	106	184	197	231	270	282
convar. *subrotunda*	92	106	180	200	212	268	280
P. italica convar. *pomariorum*							
cv. Catalan	98	108	189	210	224	274	282
convar. *claudiana*	93	105	184	204	222	269	281
convar. *ovoidea*	88	103	184	201	225	269	281
convar. *mamillaris*	92	107	183	205	226	271	282
P. syriaca convar. *cerea*	91	106	186	200	218	271	281
F-test	13.75***	19.64***	9.58***	3.12*	19.80***	25.61***	11.61**
L.S.D. 5%	1.6	0.8	2.1	7.5	7.1	2.2	1.6

* P = 5%
*** P = 0.1%

results. The petals are more conspicuous and the nectar has a higher sugar content in the practically self-sterile and self-sterile varieties, but some difference in these features exists in favour of the semi-self-fertile plums, too, compared to the self-fertile ones (Table 6).

The quotient obtained by dividing the crown diameter by the crown height characterizes the habits of plum trees. The annual shoot growth, leaf index and relative stamen number of trees with crowns tending upward are higher than the respective parameters of plums with spread crowns. The period of vegetation is longer, the fruit ripens later, and there is generally a greater number of flowers with reduced functions. The decreased size of the pistil lessens the chance of self and open pollination.

The length of pistil is in close correlation with the stamen number, pollen germination, and length of filaments and petioles. Plum varieties with longer pistils have longer filaments and pollen of higher vitality; the relative height of the stigma and anthers does not change. A relatively high stamen number (SN/PL) seems to reduce rather than increase the viability of the pollen.

The taxonomic systemization of the plum varieties and the taxonomic distribution of the genus *Prunus* itself were the subjects of lengthy discussions among botanists. The origin of the plum, which was one of the main sources of the difficulties, is still uncertain today

Table 6

Results of examination in the different fertility groups (S.F. = self-fertile; S.S.F. = semi-self-fertile; P.S.S. = practically self-sterile; S.S. = self-sterile)

Parameter	S.F. n = 12	S.S.F. n = 6	P.S.S. n = 5	S.S. n = 15	LSD 5%
Girth, cm	25.8	21.6	30.7	26.0	4.46
Girth increase, %	207	255	193	209	28.27
Crown diameter, cm	595	540	628	551	65.58
Crown height, cm	452	441	452	397	32.58
Crown quotient	1.42	1.39	1.44	1.38	0.55
Yearly shoot growth, cm	14.1	22.6	16.8	20.7	5.45
Internode length, cm	1.59	1.87	1.64	1.75	0.53
Length of leaf, mm	80.1	78.5	76.2	82.2	12.65
Width of leaf, mm	43.2	44.0	40.2	45.7	7.06
Leaf index	1.91	1.78	2.00	1.80	0.22
Length of petiole, mm	12.7	17.7	20.8	19.7	3.83
Yield, kg/tree	52.9	28.7	62.2	44.6	20.12
BBI-value	46.1	48.9	47.1	46.1	15.11
Fruit weight, g	19.4	27.2	26.8	27.7	6.79
Putamen index	4.32	4.24	4.63	3.78	2.14
Pistil length, mm (PL)	12.5	12.9	11.7	11.5	0.48
Stamen number, pc (SN)	24.5	27.9	27.3	27.0	2.02
SN/PL, n/mm	2.09	2.26	2.40	2.16	0.31
Pollen germination, %	49.7	42.7	49.4	40.1	7.12
Length of petal, mm	11.8	11.0	11.4	11.5	1.31
Width of petal, mm	8.6	9.5	8.6	8.8	0.49
Length of filament, mm					
Internal circle	5.7	5.2	5.6	5.2	1.04
External circle	8.1	7.7	7.8	7.3	1.08
Leaf-bud opening	92	92	93	91	2.3
Beginning of flowering	106	106	105	104	1.8
End of sprouting	185	182	183	181	4.0
Beginning of fruit colouration	198	198	202	202	5.4
Beginning of fruit ripening	227	217	224	221	5.8
Discolouration of leaves	271	269	270	270	4.6
Abscission of leaves	279	283	284	280	4.2

(Rybin 1936, Salesses 1975). On the basis of our morphological studies the present classification (Terpó 1974) seems to be correct and sufficiently precise to enable the taxonomic identfication of the individual varieties.

Table 7

Result of correlation calculations (n = 38)

Relationship			r-value
Crown quotient	—	Yearly shoot growth	+0.498**
		Yield per tree	+0.250
		Leaf index	+0.583***
		Pistil length	—0.213
		SN/PL	+0.452**
		Beginning of fruit colouration	—0.468**
		Beginning of discolouration of leaves	—0.526***
		End of vegetation	+0.466**
Pistil length	—	Stamen number	—0.715***
		Average diameter of petal	+0.457**
		Pollen germination	+0.321+
		Length of filament	
		Internal circle	+0.829***
		External circle	+0.871***
		Length of petiole	+0.372*
SN/PL	—	Pollen germination	—0.487**
		Average diameter of petal	—0.403*
Yie d per tree	—	BBI-value	—0.356*
		Fruit weight	+0.288+
End of vegetation	—	Leaf-bud opening	—0.746***
Leaf-bud opening	—	Beginning of flowering	+0.416*
		End of sprouting	+0.398*
End of sprouting	—	Beginning of discolouration of leaves	+0.932***
Beginning of leaf discolouration	—	Beginning of leaf abscission	+0.994***
Beginning of flowering	—	Beginning of discolouration of leaves	+0.753***
		Beginning of abscission of leaves	+0.625***
Beginning of fruit colouration	—	Beginning of ripening	+0.542***
Beginning of fruit ripening	—	Beginning of leaf discolouration	+0.615***

+ P = 10%; * P = 5%; ** P = 1%; *** P = 0.1%

The systemization of plum varieties is made difficult by the large number of varieties of uncertain origin; and the synonyms of some varieties may be a source of further confusion. The plum varieties have different ploidy levels: *P. cerasifera* and *P. domestica* are hexaploid (2n = 48), while *P. spinosa* has a varying number of chromosomes (2n = 16, 24, 32, 40, 48). If the chromosome analysis of *P. italica* and *P. syriaca* really demonstrates higher ploidy level, then the origin of *P. italica (P. domestica* × *P. insititia)* and of *P. syriaca (P. domestica* × *P. cerasifera)* can be accepted as a fact.

The varying chromosome number sometimes increases and sometimes decreases the fertility of the *Prunus* varieties, so the clarification of this question is definitely not the exclusive task of botanists and genetists. CRANE—LAWRENCE (1952) do not deal in their book with the relationship between ploidy level and stamen number, although this was actually established by MORRISON (1964); according to our investigations the reduced number of stamina in the species of the subfamily *Prunoideae* is accompanied by a higher chromosome number. The number of stamina is in fact a varietal character, provided they are obtained from a bearing spur, since the number of stamina in flowers differentiated on wild offshoots is significantly lower (SURÁNYI—TÓTH 1977). The pistil length shows a greater annual fluctuation than the stamen number (SURÁNYI 1976).

High fertility (self and open pollination) requires a pistil at least 10 mm in length, as in most *Prunoideae* pistils of this size contain fully developed ovaria. In the worst cases the pistil is undeveloped, so fruit formation hardly occurs. The I/15 clone of cv. Alutscha, for example, produces pistils unable to function; the structural sterility is indicated by the shortness of the flower stem itself (SURÁNYI—TÓTH 1976).

To sum up, it can be stated that the major results of several years of investigations are in full agreement with those reported in the most important papers; a large proportion of the varieties included in our observations are found in all the publications (DAHL 1935, RÖDER 1940, RÉMY 1954, TÓTH 1957, 1975).

Most self-fertile plum varieties belong to the *P. domestica* group, where the pistil is developed and the number of stamina is generally small; they are fertilised by their own pollen relatively well even under unfavourable weather conditions. Easily fertilized varieties are comparatively rare in other taxa (Angoulème, Giant, Yellow mirabelle, Septembrische Mirabelle); they are more sensitive during the flowering period than the varieties in the *domestica* group.

An explanation has also been found, more or less, as to why the pistil is longer and the number of stamina smaller in semi-self-fertile varieties when compared with self-fertile ones (SURÁNYI 1978). Some of these varieties (at least according to investigations made so far) belong to the group of eggplums and date-plums, which are characterized by a long pistil (and large average fruit weight). And their leaves are longish, oval in shape. The vegetative production of these varieties is higher than that of the self-fertile ones, but this does not bring about an increase in productivity.

KOBEL (1954) is quite right when he states that the correlation between the structure and function (fructification) of the flower is not always manifested. Indeed, self-fertility cannot be explained by the relative height of anthers and stigma, since the relative stigma-anther height is a fixed property; this explanation is also excluded by the positive correlation between pistil length and filament length. The views of RÖDER (1940) and RÉMY (1954) are thus rejected by TÓTH (1975) on reasonable grounds. The correlation between gynoecium and androecium, on the other hand, has been consistently proved, and this is connected with self-fertility; the correlation between relative stamen number and percentage self-fertility is also significant in linear regression (SURÁNYI 1978, SURÁNYI—TÓTH 1977).

The relative number of stamina and the habit of the tree are closely related to each other. Both are varietal characters, as are the putamen index, the leaf index, the shape of the petal, and the phenophases of flowering, leaf-bud opening, fruit ripening, discolouration and abscission of leaves. By making use of these characteristics the varieties can be put in their correct taxonomic places, and in possession of the new data accumulated so far our work can be concentrated in future on thorough research into the origin of the plum.

*

Prepared at the Fruit Research Station, Cegléd

D. SURÁNYI

References

Brózik S. (1960): Szilva — Kajszi (Plum and apricot varieties). Mezőgazdasági Kiadó, Budapest, 72.

Crane, M. B.—Lawrence, W. J. C. (1952): The genetics of garden plants. MacMillan Co. Ltd., London, 301.

Dahl, C. L. (1935): Morphological studies of plum flowers. Meded. fran. perm. komm. för Fruntadlingsförsök., **38,** 1—93.

Haskell, G.—Dow, P. (1955): The stamen pattern of cultivated plums. Ann. Bot., **199,** 467—484.

Kobel, F. (1954): Lehrbuch des Obstbaues auf physiologischer Grundlage. Springer, Berlin—Göttingen—Heidelberg, 348.

Löschnig, H. J.—Passecker, F. (1954): Die Marille (Aprikose) und ihre Kultur. Österr. Agrarverl., Wien, 324.

Morrison, J. W. (1964): The stamen number of some fruit species and varieties grown at Morden, Manitoba. Proc. Amer. Soc. Hort. Sci., **84,** 123—130.

Rémy, P. (1954): Contribution a l'étude du pollen des arbres fruitiers à noyau, genre *Prunus*. Ann. Amél. Plant., **3,** 351—388.

Röder, K. (1940): Sortenkundliche Untersuchungen an *Prunus domestica*. Kühn-Archiv B., **54,** 1—133.

Rybin, V. A. (1936): Spontane und experimentell erzeugte Bastarde zwischen Schwarzdorn und Kirschpflaume. Planta, **25,** 22—58.

Salesses, G. (1967): Connaissances cytogénétiques et hibridation interspecifique dans le sousgenre *Prunophora*, section *Euprunus*. Ann. Amél. Plant., **17,** 379—408.

Salesses, G. (1970): Études cytologiques chez les *Prunus*. I. Espèces de la section *Euprunus*. Ann. Amél. Plant., **20,** 469—483.

Salesses, G. (1973): Études cytologiques chez les *Prunus*. II. Hybrides impliquant les espèces *P. cerasifera*, *P. spinosa* et *P. insititia*. Ann. Amél. Plant., **23,** 145—161.

Salesses, G. (1975): Quelques données concernant la cytogenetique des pruniers et l'origine du prunier domestique. Acta Hort., **48,** 59—65.

Schumacher, R. (1965): Regulierung des Fruchtansatzes. Ulmer, Stuttgart. 134.

Surányi D. (1970): A csonthéjasok termékenyülési viszonyainak mutatója: a virág index (Flower index, an indicator of fertility conditions in stone fruits). Bot. Közlem., **57,** 135—138.

Surányi D. (1974): Correlation between gynoecium and androecium in *Prunoideae* species. Acta Hort. Hung., **20,** 379—388.

Surányi, D. (1976): Differentiation of self-fertility and self-sterility in *Prunus* by stamen number/pistil length ratio. Hort. Sci., **11,** 406—407.

Surányi, D. (1978): A new method to determine self-fertility in plums and gage varieties. Acta Agron. Hung., **27,** 247—257.

Surányi D.—Tóth E. (1976): Sterilitás-megfigyelések Alutscha szilvafajtán (Sterility studies on the plum variety Alutscha). Bot. Közlem., **63,** 249—257.

Surányi D.—Tóth E. (1977): Szilvafajták porzószámának vizsgálata (Study of stamne number in plums). Kertgazdaság, **9,** 41—51.

Terpó A. (1974): Gyümölcstermő növényeink rendszertana és földrajza (Taxonomy and geobotany of fruit-bearing plants). In: A gyümölcstermesztés alapjai (The fundamentals of fruit growing). Mezőgazdasági Kiadó, Budapest, 139—219.

Tóth E. (1957): Élet- és alaktani összehasonlító vizsgálatok szilvafajtákon (Comparative biological and morphological studies on plum varieties). Kert. Kut. Int. Évk., **2,** 11—129.

Tóth E. (1975): A szilva termékenyülési viszonyai (Fertility relations in plums). In: Gyümölcstermő növények termékenyülése (Fertility of fruit-bearing plants). Mezőgazdasági Kiadó, Budapest, 158—172.

Vondráček, J. (1975): The study of some phenophases in plums. Acta Hort., **48,** 23—34.

EFFECT OF SOME MICRO-NUTRIENTS ON THE YIELD, YIELD COMPONENTS AND PROTEIN CONTENT OF MEXIPAK WHEAT CULTIVAR (T. AESTIVUM L.)

Wheat responds well to applications of commercial fertilizer in most areas of the world. Macro- and micro-nutrients are generally recommended because they not only increase the yield and quality of grain, but they provide assurance for the successful establishment of the new seeding as well. In Egypt, since the construction of the Aswan Dam, clay which contains macro- and micro-nutrients is precipitated in front of the dam. In the long run the Egyptian soil may be fertilized by larger quantities of micro-nutrients as well as by commercial fertilizers. The aim of the present investigation was to study the effect of some micro-nutrients on the yield, yield components and grain content of Mexipak wheat. SHARMA—WADERMA KUMAR (1971) and YAFACO *et al.* (1973) showed that applying Mn or Zn to wheat increased the grain yield, the quality of the grains, the number of grains/ear and the 1000-grain weight. SERRY *et al.* (1973) found that Zn increased the yield markedly by 33% whereas with Zn + Mn or Zn + Mn + Fe the increase in grain production was found to be 26% and 29% respectively. DAMIDENKO—BARINOVA (1940) reported that Mn or Zn increased both the green part and the grain.

This investigation was carried out at the Faculty of Agricultural Science Experimental Farm, Moshtohor, Kalubia, Egypt, during the 1974/75 and 1975/76 seasons. Wheat seeds of the variety Mexipak (*T. aestivum* L.) were sown in the second week of November at a rate of 216 kg/ha. The seeds were broadcasted and then irrigated. All treatments received the same quantities of phosphatic and nitrogenous fertilizers. The rate of phosphatic fertilizer was 38.4 kg P_2O_5/ha in the form of superphosphate (16% kg P_2O_5). Nitrogen was applied at a rate of 144 kg N/ha in the form of urea (46% N). The phosphorus fertilizer was broadcasted at sowing time while the nitrogen fertilizer was applied before the first irrigation (one month after sowing). A randomized complete block design with 4 replications was used. The area of each plot was 10.5 m^2 (3×3.5 m). The experiment was irrigated four times during the growth period. The type of soil used was clay loam. The treatments were control, Fe, Mn, Zn, Fe + Mn, Fe + Zn, Mn + Zn and Fe + Mn + Zn. The micro-nutrients were applied as a foliar spray in the form of chelated Na_2Fe (8% Fe), Na_2Mn (15% Mn) and Na_2Zn (14.2% Zn). The concentration of the whole chelate in the solution was 0.2%. The amount of solution for every substance was 1440 litres/ha (1.5 litres/plot). Every micro-nutrient alone or in combination was separately sprayed once, approximately three weeks before heading. Data on growth and yield components were estimated from a 10-plant sample taken at random from each plot at maturity. The grain yield and straw yield were calculated from the yield of all the plots. Ten plants were collected at random at the beginning of heading (3 weeks after applying the micro-nutrients) to determine the fresh weight and dry weight per plant. Samples of kernels were collected at random from each plot and used for the determination of crude protein according to the Kjeldahl method described in the A.O.A.C. (1970) recommendations. The yield of crude protein is also given as a percentage of the grain yield (kg/ha). Data obtained for the following characteristics, plant height, fresh weight per plant, dry weight per plant, spike length, spike number per plant, kernel number per spike, spike weight, kernel weight per spike, 1000-kernel weight, grain yield (kg/ha), straw yield (kg/ha) and protein content/grain were subjected to analysis of variance, and Duncan's multiple range test was used to separate the means. Combined analysis was used for all agronomic characteristics except the fresh weight/plant and dry weight/plant, which were calculated from the average of the two seasons. Soil samples from the experimental farm were taken (0—40 cm depth) and subjected to chemical analysis as shown in Table 1.

The chemical analysis for the macro-nutrients and pH was carried out according to JACKSON (1958) and for the micro-nutrients according to CHAPMAN—PRATT (1961).

Table 1

Chemical analysis of soils collected from the experimental farm

Saturated soil paste, m.eq./l				Suspension 1 : 2.5	Available, N	Available			
						Mn	Zn	P	Fe
K	Na	Ca	Mg	pH	%	ppm/100 g soil			
0.93	6.53	5.73	8.87	8.1	0.068	190	5	50	120

Yield Components. Table 2 shows that the plant height was significantly decreased by applying Fe + Mn + Zn as compared with the other treatments, except for the control and the Mn treatment. The spike length significantly increased by applying Mn, Zn, Fe + Mn or Mn + Zn, while it was not affected by applying Fe alone or Fe + Mn + Zn. The greatest spike length was obtained with Zn application.

The fresh weight per plant significantly increased in all treatments except those including Fe and Fe + Mn, whereas the other treatments were ineffective. The highest fresh weight and dry weight per plant were obtained by applying Mn + Zn, whereas the lowest fresh weight and dry weight per plant were obtained from Fe + Zn and the control, respectively. The increases in the fresh weight per plant probably resulted from an increase in plant height. These results are in good agreement with those obtained by DAMIDENKO—BARINOVA (1940).

Table 2 indicates that the differences in the number of spikes per plant due to the Mn, Zn, Fe + Zn, Mn + Zn and Fe + Mn + Zn treatments were significant. The spike number per plant reached its maximum when Fe + Mn + Zn was applied, which gave an increase of 1.31 over the control treatment. There was in increase in the kernel number per spike due

Table 2

Combined analysis of two years for some yield components of Mexipak Wheat cultivar as affected by some micro-nutrients

Characteristics Treatments	Plant height, cm	Fresh weight, g/plant	Dry weight, g/plant	Length of spike, cm	Number of spikes per plant	Number of kernels per spike
Control	105.08 ab	40.37 a	11.13 a	7.38 a	3.00 a	27.96 a
Fe	106.28 b	45.25 ab	11.58 a	8.38 ab	3.47 b	36.65 d
Mn	103.43 ab	51.95 b	13.03 a	8.66 bc	3.51 a	37.96 f
Zn	106.03 b	50.75 b	12.68 a	9.40 d	3.95 c	39.53 g
Fe + Mn	108.93 cb	47.25 b	12.40 a	9.10 d	3.06 a	33.23 b
Fe + Zn	106.56 cb	37.75 a	11.75 a	8.50 bc	3.41 b	36.44 c
Mn + Zn	103.68 cb	68.75 c	14.73 a	8.47 bc	4.19 d	37.09 e
Fe + Mn + Zn	101.07 a	51.75 b	12.58 a	8.22 ab	4.31 d	46.59 b
	+	++	—	++	++	++
F Value	2.62	12.40	0.498	32.0	19.20	113.44

+ and ++ = Significant at 5% and 1% level, respectively.

Any two values within the same characteristics not followed by the same letter are significantly different at the 5% level of probability according to Duncan's new multiple range test.

to the application of the micro-nutrients under study. The highest kernel number per spike resulted from the Fe + Mn + Zn treatment, showing an increase of 66.6% over that of the control treatment. The differences between the kernel number per spike due to the micro-nutrients were significant. The increase in kernel number per spike is naturally due to an increase in the number of fertile flowers per spike. This result is in good agreement with that obtained by SHARMA—WADERMA KUMAR (1971).

Table 3 shows that the mean weight of the spike was significantly increased by all the micro-nutrient treatments under study. The Zn treatment gave the highest spike weight. The effect of micro-nutrient treatments on the spike weight was primarily due to an increase in the kernel number per spike and the spike length. These results agree with those obtained by KALTYA (1941) who showed that Mn improved spike filling. The weight of kernels per spike was also significantly increased by the micro-nutrient treatments except in the case of the Fe and Fe + Mn treatments where the resulting increases were not significant. The weight of kernels per spike reached its maximum in the Fe + Mn + Zn treatment. This increase was probably due to an increase in the kernel number per spike and the 1000-kernel weight. The 1000-kernel weight was significantly increased when the micro-nutrients studied were added either separately or combined. The highest increase in the 1000-kernel weight (17.75 g) was obtained from the treatment of Fe + Mn + Zn while the lowest increase (4.13 g) was obtained from the treatment of Fe + Zn as compared with the control. These results agree with those obtained by SHARMA—WADERMA KUMAR (1971) and HEFNI (1973), who emphasized that Mn and Zn increased the weight of the grains and the 1000-kernel weight of wheat.

Grain Yield. The application of micro-nutrients significantly increased the grain yield of wheat (Table 3). The grain yield reached its maximum when the plants received Fe + Mn + + Zn. The increase in the grain yield was 2019.6 kg/ha over the control. It is evident that the increase in the grain yield was primarily due to increases in the number of spikes per plant,

Table 3

Combined analysis of two years for the yield, some yield components and protein content of grain of Mexipak wheat cultivar as affected by some micro-nutrients

Characteristics Treatments	Weight of spikes, g	Weight of kernels per spike, g	1000-kernel weight, g	Grain yield, kg/ha	Straw yield, kg/ha	Crude protein, %	Crude protein, kg/ha
Control	1.91 a	1.26 a	26.00 a	4855.2 a	818 ab	8.76	425.52
Fe	2.16 b	1.38 abc	32.50 c	5868.0 c	907 c	8.83	518.16
Mn	2.23 bc	1.45 c	41.88 cf	6026.4 c	900 e	8.87	534.48
Zn	2.43 c	1.58 d	39.75 e	6590.4 d	816 ab	8.87	573.36
Fe + Mn	2.31 bc	1.33 a	37.13 d	5311.2 b	1010 d	8.26	438.72
Fe + Zn	2.31 c	1.50 cd	30.13 b	5904.0 c	876 be	8.44	502.32
Mn + Zn	2.17 b	1.50 cd	31.75 bc	5911.2 c	883 be	8.51	546.96
Fe + Mn + Zn	2.15 b	1.70 e	43.75 f	6864.0 d	811 a	9.12	627.12
	++	++	++	++	++	—	—
F Value	20.00	30.00	90.16	30.26	857		

++ = Significant at 1% level.

Any two values within the same characteristics not followed by the same letter are significantly different at the 5% level of probability according to Duncan's new multiple range test.

the kernel number per spike, the kernel weight per spike and the 1000-kernel weight. These results agree with those obtained by SHARMA—WADERMA KUMAR (1971) who showed that the increase in the grain yield was obtained from an increase in the number of grains per ear and the 1000-grain weight when Zn was applied. The results of the present investigation also agree with those obtained by DAMIDENKO—BARINOVA (1940), DHILON *et al.* (1971), RAMSNEHI—RANDHAWA (1973), SERRY *et al.* (1973), YAFACO *et al.* (1973) and TAKKAR *et al.* (1973), who indicated that the addition of Mn, Zn or Fe + Zn increased the grain yield and the grain content of protein and carbohydrate.

Straw Yield. The Fe, Mn and Fe + Mn treatments gave significant increases in the straw yield (Table 3), while the other treatments where not effective. The Fe + Mn + Zn treatment gave the lowest straw yield compared with the other treatments. Significant differences were obtained between the mean straw yield given by the Fe + Mn + Zn treatment and the other treatments, except for the control and the Zn treatment. The increase in the straw yield may be associated with the observed increases in the plant height and dry weight per plant (Table 2).

The combined analysis indicated that most of the characteristics studied were significantly affected by the micro-nutrient treatments. However, years × micro-nutrient treatments had insignificant effects on the plant height, the number of tillers and spikes per plant as well as the straw yield.

Protein Yield. Table 3 shows that the protein yield/ha increased when applying the micro-nutrients under study. The combination of Fe + Mn + Zn gave the highest protein yield, followed by the Zn treatment, then the Mn treatment. This result is in good agreement with that obtained by RAMSNEHI—RANDHAWA (1973) who showed that Mn, Zn or Fe + Zn increased the grain content of protein. The combination of Fe + Mn decreased the protein yield as compared with Fe or Mn alone. This result is in good agreement with that obtained by SOMERS—SHIVE (1942). The crude protein percentage was not affected by adding the micro-nutrients under study. This means that the increase in protein yield/ha was due mainly to the observed increase in yield/ha.

*

Prepared at the Agronomy Department, Faculty of Agricultural Science, Moshtohor, Kalubia.

EL-S. H. M. HEFNI

References

A.O.A.C. (1970): Official Methods of Analysis. Ass. Offic. Agric. Chem., Washington, D.C.

CHAPMAN, H. D.—PRATT, P. F. (1961): Methods of analysis for soils, plants and waters. Div. of Agric. Sci., Univ. of California.

DAMIDENKO, T. T.—BARINOVA, R. A. (1940): Yield and composition of spring wheat in relation to microelements. Compt. Rend. Acad. Sci. U.S.S.R., **26**, 291—293.

DHILON, G. S.—PANWAR, B. S.—GUPTA, A. K. (1971): Micro-nutrient studies on semidwarf wheat (Lerma Pojo). Indian Journal of Agronomy, **16**, 268—270.

HEFNI, EL-S. H. M. (1973): Influence of macro-nutrient, micro-nutrient and two types of soil on the growth and grain contents of spring wheat. Research Bull. No. 19 July, Moshtohor, Kalubia, Egypt.

JACKSON, M. L. (1958): Solid Chemical Analysis, Constable and Co. Ltd., London, 38—325.

KALTYA, A. (1941): Infleunce of Mn on spring wheat. Compt. Rend. Acad. Sci. U.R.S.S., **81**, 383—384.

RAMSNEHI, D.—RANDHAWA, N. S. (1973): Zinc nutrition and the energy value of cereal grains. Current Sci., **42**, 61—62.

SERRY, A.—MAWARDI, A.—AWAD, S.—ABDEL-AZIZ, I. (1973): Effect of zinc and manganese on wheat production. Improvement and production of field food crops. First FAO/STDA Seminar for plant scientists from Africa and Near East, Cairo, Egypt, 1—20 September.

SHARMA, K. C.—WADERMA KUMAR (1971): A note on zinc nutrition studies in dwarf wheat under field condition. Plant Sci., **3**, 123—125.
SOMERS, I. I.—SHIVE, J. M. (1942): The iron-manganese relation in plant metabolism. Plant Physiol., **17**, 582—602.
TAKKAR, P. N.—MANN, M. S.—RANDHAWA, N. S. (1973): Major Zahi (winter) and Kharif (Summer monsoon) crops respond to zinc. Indian Farming **23** (8), 16—24.
YAFACO, A. V.—ANFEROVA, V. N.—AKCHERIN, M. M. (1973): Direct and residual effect of foliar application of Mo and Mn on grain yield and quality of spring wheat. J. Agr. Sci. U. K., **81**, 269—273.

INHERITANCE OF MALE STERILITY IN SQUASH, CUCURBITA PEPO L.

During the breeding programme for obtaining gynoecious flowers in squash by selfing and selection, the senior author observed a number of male sterile plants. All the plants in this population were selfed or crossed and used for inheritance studies. This character is important as it enables efforts to be saved in crossing, in addition to its value in obtaining heterosis.

Eisa was the first to discover male sterility in squash in Egypt in 1961. The inheritance of this character was investigated by EISA—MUNGER (1968) and GANAPATHY—HABIB (1969).

The Eskandarany cultivar of squash was used in the Faculty of Agriculture, Cairo University, at Giza from 1973 to 1976. Planting was carried out in five seasons during this period, namely Nili (autumn) 1974 and summer 1973 to 1976. The first observation of male sterile plants was in Nili 1974.

These plants were pollinated by the fertile sibs and the progeny were selfed or crossed to each other. This was done each season until 1975. The seed material was planted in the field in summer 1976 to obtain data.

The chi square test was used to evaluate this qualitative character.

The results shown in Table 1-A indicate that, when the first discovery of male sterility in squash was made, population 27—8 (March 1974) segregated according to a ratio of 3 fertile: 1 male sterile plants with a χ^2 value of 0.1304 and a P value of 0.50—0.75.

The five male sterile plants from this population were crossed with their fertile sibs and planted with their selfed fertile sibs in July 1974. The fertile and male sterile plants from this Nili planting were grown in March 1975 and finally the progenies of fertiles and male steriles were planted in March 1976.

Most of the selfed plants (Table 1-B) segregated in each population to fit the ratio 3 fertile : 1 sterile with P values ranging from 0.10 to >0.995. The pooled data of these populations showed a heterogeneity χ^2 value of 3.9823 and a P value of 0.75—0.90 on the basis of a 3 : 1 ratio.

When the fertile plants were crossed with each other (Table 1-C) most of them segregated in a manner similar to that reported for the selfed plants, indicating that the parent plants were heterozygous.

With respect to the male sterile plants which were crossed with fertile sibs, the data were divided into two groups. The first (Table 1-D), the progenies of male sterile plants pollinated with heterozygous fertiles, segregated with a ratio of 1 : 1 for each progeny with P values ranging from 0.10 to >0.995. The second (Table 1-E), the progenies of male plants pollinated with homozygous fertiles, consisted of fertiles only, as would be expected.

Thus, the fertile-sterile phenotype was dependent for its expression upon a single pair of genes (Msms), where the dominant gene produces fertile plants and the recessive gene results in sterility.

Table 1

Expression of male sterility in progenies of heterozygous plants selfed or crossed with male steriles

Pedigree	No. of observed plants		Ratio	χ^2	P
	Fertile	Sterile			
A) **Selfed parent of genotype Msms (1974)**					
27— 8	18	5	3 : 1	0.1304	0.50—0.75
B) **Selfed parents of genotype Msms (1976)**					
30—8	8	3	3 : 1	0.0303	0.75—0.90
35—8	3	1	3 : 1	0.0000	>0.995
35-15	13	3	3 : 1	0.3333	0.50—0.75
37-7	5	3	3 : 1	0.6667	0.25—0.50
38-1	14	6	3 : 1	0.2667	0.50—0.75
38-33	14	3	3 : 1	0.4901	0.25—0.50
38-25	2	1	3 : 1	0.1111	0.50—0.75
38-28	6	5	3 : 1	2.4545	0.10—0.25
Total χ^2				4.3527	0.75—0.90
Pooled χ^2	65	25	3 : 1	0.3704	0.50—0.75
Heterogene ity χ^2				3.9823	0.75—0.90
C) **Crossing parents of the same genotype Msms (1976)**					
30-3 × 30-4	15	2	3 : 1	1.5883	0.10—0.25
32-5 × 38-20	9	2	3 : 1	0.2727	0.50—0.75
33-3 × 33-2	8	2	3 : 1	0.1333	0.50—0.75
34-10 × 38-13	8	2	3 : 1	0.1333	0.50—0.75
35-6 × 35-10	3	1	3 : 1	0.0000	>0.995
38-2 × 38-1	14	2	3 : 1	1.3333	0.10—0.25
38-9 × 38-22	12	1	3 : 1	2.0769	0.10—0.25
38-21 × 38-22	18	2	3 : 1	2.4000	0.10—0.25
38-22 × 38-5	18	3	3 : 1	1.2857	0.25—0.50
Total χ^2				9.2235	0.25—0.50
Pooled χ^2	105	17	3 : 1	7.9672	0.25—0.50
Heterogeneity χ^2				1.2563	>0.995
D) **F_1 from maternal parent Msms and paternal parent Msms (1976)**					
30-7 × 30-8	10	8	1 : 1	0.2222	0.50—0.75
31-16 × 30-5	3	3	1 : 1	0.0000	>0.995
32-2 × 32-4	1	1	1 : 1	0.0000	>0.995
32-11 × 32-4	6	2	1 : 1	2.0000	0.10—0.25
34-1 × 34-9	2	4	1 : 1	0.6667	0.25—0.50
34-3 × 38-2	13	16	1 : 1	0.3104	0.50—0.75
35-12 × 35-5	5	8	1 : 1	0.6923	0.25—0.50
35-16 × 38-21	11	5	1 : 1	2.2500	0.10—0.25
35-17 × 35-15	7	7	1 : 1	0.0000	>0.995
Total χ^2				6.1416	0.50—0.75
Pooled χ^2	58	54	1 : 1	0.1429	0.50—0.75
Heterogeneity χ^2				5.9987	0.50—0.75
E) **F_1 from maternal msms and paternal parent MsMs (1976)**					
35-13 × 35-16	9	—			
35-14 × 35-19	14	—			

The following factorial analysis is suggested:

P_1	msms		Male sterile
P_2	MsMs		Male fertile
F_1	Msms		Male fertile
F_2	MsMs 1	3	Male fertile
	Msms 2		
	msms 1		Male sterile
BC_{m_1}	Msms 1		Male fertile
	msms 1		Male sterile
BC_{P_2}	MsMs, Msms		Male fertile

The data reported by EISA—MUNGER (1968) and GANAPATHY—HABIB (1969) were in accordance with the present results, which indicate that sterility is controlled by a single recessive gene.

*

Prepared at the Department of Horticulture, Faculty of Agriculture, Cairo University, Cairo.

A. A. ABD EL-HAFEZ, A. H. KHEREBA

References

EISA, H. M.—MUNGER, H. M. (1968): Male sterility in squash, *Cucurbita pepo* L. Proc. Amer. Hort. Sci., **92**, 473—479.

GANAPATHY, M. C.—HABIB, A. F. (1969): Male sterility in squash (*Cucurbita pepo* L.). Mysere Agric. J., **3**, 339—341.

THE SUITABLE PROTEIN LEVEL FOR FEEDING DAIRY CATTLE. I. MAINTENANCE REQUIREMENTS

Feeding dairy animals with more or less protein than their maintenance requirements caused various changes in body weight, nitrogen balance and blood composition. It has been well documented that a liberal protein intake tends to cause a high level of deposit "protein". On the other hand, it is recognized that protein in excess of what the body can use is wasted in so far as its specific functions as protein are concerned, since it cannot be stored in any tissue, though very limited amounts can be stored as fat. A large excets of protein in terms of body need increases the work of the kidneys in the excretion of urea, which has been shown to be an undesirable and possibly dangerous substance.

On the other hand, when the supply of dietary protein is not enough to maintain the N-balance in equlibrium, tissue protein is catabolized.

It is of vital economic importance to reduce the feeding cost by feeding proper feeding allowances, which should be a little more than the minimum requirements, allowing a relatively small margin of safety in practical feeding.

The aim of this study was to determine the most economic protein level for maintenance. The nitrogen balance and certain blood constituents were also studied.

The experiment was undertaken at the Animal Production Station, Faculty of Agriculture, Assiut University. Four feeding trials were performed with 14 Jersey bulls and 8 non-lactating, non-pregnant Jersey cows to study the suitable protein level for maintenance. Each

Table 1

Feeding stuffs, starch value and D.C.P. of mixtures fed to animals in different experiments

Feeding stuffs	Trials			
	I	II	III	IV
Undercorticated cotton seed cake, %	10.0	5.0	5.5	—
Maize, %	30.0	25.0	33.0	10.0
Wheat bran, %	15.0	10.0	16.5	10.0
Unified feed mixture,* %	—	—	—	10.0
Wheat straw, %	45.0	60.0	45.0	70.0
Starch value (S.V.), %	45.98	41.57	41.03	51.05
D.C.P., %	4.58	3.23	2.76	3.00

* Unified feed mixture contains: 45% undecorticated cotton seed cake, 26% wheat bran, 7% rice bran, 17% maize, 2% molasses, 2% calcium carbonate and 1% sodium chloride.

trial lasted 11 weeks and was divided into a transitional (2 weeks) and a test period (9 weeks) according to MORIMOTO *et al.* (1963).

In trial I, four Jersey bulls and two Jersey dry cows were used to test the level of 50 g digestible protein (D.P.) per 100 kg live weight (L.W.) as the maintenance requirement. In trial II, four Jersey bulls and two Jersey dry cows were used to study the level of 40 g D.P. In trial III, two Jersey bulls and two dry cows were used to test the level of 30 g D.P., while in trial IV, four Jersey bulls and two Jersey cows were employed to check the level of 37.5 g D.P. The animals used were over two years old, healthy and in good condition and were under veterinary supervision during the whole experimental period.

The energy level intake was kept constant during all the experiments at 0.50 kg starch value/100 kg L.W., as recommended by GHONEIM (1958). The feeding stuffs used in the four mixtures are found in Table 1. The feeding value and digestible protein of the mixtures were calculated on the basis of four digestibility trials with sheep.

The animal were individually fed and water was available at all times. Before starting the trial, the animals were weighed to estimate the maintenance requirement, and were thereafter weighed weekly throughout the experimental period and at the end of the trial. Weighing was always carried out at 8 a.m. before the ration was given. Three successive weights were averaged to the nearest half kg.

In each trial, during the last two weeks a nitrogen balance was carried out with two Jersey cows. The faeces and urine were collected in suitable bags. Samples of blood from the jugular vein were taken from each cow and bull immediately before giving the morning feed. The total nitrogen and NPN were determined by the Kjeldahl method using 10% tricholoroacetic acid to separate the true protein. Urea-N was determined gasometrically by the method of Coversky (PETROONKINA 1961).

The chemical analysis of feeding stuffs and faecal material followed the ordinary conventional methods (A.O.A.C. 1960).

Statistical analysis of the available data was undertaken according to SNEDECOR (1967).

Body weight change. The effect of feeding different levels of D.C.P. as maintenance requirements on body weight change are presented in Table 2. These results indicated that animals receiving 50 g D.C.P./100 kg L.W. (trial I) showed a significant increase ($P < 0.01$) in

Table 2

Effect of feeding different levels of D.C.P. as maintenance requirements on body weight change

Item	Trials			
	I (50 g)	II (40 g)	III (30 g)	IV (37.5 g)
Initial body weight, kg	300.0 ± 27.7	321.5 ± 44.7	378 ± 123.6	333.2 ± 57.1
Final body weight, kg	325.8 ± 38.5	331.6 ± 43.3	344 ± 117.9	333.2 ± 59.1
Body weight change, kg	25.8 ± 11.8	10.1 ± 7.1	—34 ± 6.9	0.0 ± 8.9
Change from the intial, %	7.5 ± 3.4	3.1 ± 2.4	—8.99 ± 1.4	0.0 ± 2.7
Av. daily gain or loss, kg	0.3 ± 0.15	0.13 ± 0.09	—0.42 ± 0.09	0.0 ± 0.1
Daily S.V. intake, kg	1.5	1.61	1.9	1.67
Daily D.C.P. intake, g	150.0	128.6	113.4	124.9

body weight. Expressing this change as a percentage of the initial weight, the corresponding figure was 7.5 ± 3.4%. These results clearly indicated that this level was more than that required for maintenance, as such a level permits the animal to gain weight.

Reducing the level of D.C.P. to 40 g/100 kg L.W. (trial II) also caused a significant ($P < 0.05$) increase in body weight, but this increase in weight was lower (3.14 ± 2.4% of the initial weight) than that in trial I. Therefore, this level also appeared to be higher than the minimum protein requirement for maintenance.

On the other hand, feeding animals at a more reduced level (30 g D.C.P./100 kg L.W., trial III) caused a loss in body weight. The loss represented 8.99 ± 1.4% of the initial weight.

It may be seen from the above results that the change in animal body weight was positive when the animals received high protein levels (40 or 50 g D.C.P./100 kg L.W.); in contrast, this change was negative when the animals were fed 30 g D.C.P./100 kg L.W. Moreover the average daily loss in body weight resulting from feeding 30 g D.C.P. was more than the average daily gain obtained by feeding 40 g D.C.P. (0.42 ± 0.09 kg as opposed to 0.13 ± 0.09 kg daily).

These results led to the assumption that the D.C.P. level required for maintenance not only lies between the levels 40 and 30 g but also approaches the higher limit. It was possible by interpolation from the data of these two levels, to calculate that perhaps 37.5 g D.C.P./100 kg L.W. would be the minimum protein level for maintaining constant body weight.

The effect of this level (37.5 g) was tested in trial IV. It may be observed that for animals fed at this level (Table 2) the initial body weight remained constant. The average change (as a percentage of the initial weight) was practically nil, being 0.00 ± 2.7%.

Preston (1972) reported that the D.C.P. required for 100 kg L.W. was 32.3 g as a maintenance requirement, while Hashizume *et al.* (1964) suggested that the maintenance requirement for protein ranged from 48.4 to 53.9 g/100 kg L.W. In Egypt, Ghoneim (1958) reported that the protein requirement for maintenance was 50 g D.C.P./100 kg L.W.

N-balance. The N-intake, N-excretion (in faeces and urine) and N-retention at different levels of digestible nitrogen intake are presented in Table 3. In all the nitrogen balance trials, except those fed the lowest level of D.C.P. (30 g), all the animals had a positive N-balance. However, the amount of N retained varied according to the level of digestible nitrogen intake.

The results in Table 3 show that the two higher levels (40 and 50 g D.C.P.) provided the animals with more protein than that required for maintenance. On the other hand, when the animals received the lowest level (30 g) they had a negative N-balance. This indicated that this level was not enough to provide the animals with the protein required for maintenance.

Table 3

Effect of the dietary protein level on be N-balance

Item	Trial I (50 g D.C.P./ 100 kg L.W.)		Trial II (40 g D.C.P./ 100 kg L.W.)		Trial III (30 g D.C.P./ 100 kg L.W.)		Trial IV (37.5 g D.C.P./ 100 kg L.W.)	
	Cow 1	Cow 2	Cow 1	Cow 2	Cow 1	Cow 2	Cow 1	Cow 2
Animal L.W., kg	326.00	332.00	369.00	361.00	345.00	345.00	384.00	374.00
N intake, g/day	55.40	56.40	54.60	53.40	31.40	31.40	56.80	55.30
D.N. intake, g/day	26.32	26.80	23.83	23.30	16.58	16.58	23.08	22.47
N output (faecal + urinary N), g/day	27.46	30.00	51.67	48.24	44.30	39.50	53.89	51.54
N balance, g/day	27.94	26.40	2.93	5.16	—12.90	— 8.10	2.91	3.76
% N intake	50.40	46.40	5.40	9.70	—41.10	—25.80	5.10	6.80

The results of N-balance tests with the 37.5 g D.C.P./100 kg L.W. level indicated that a small amount of nitrogen was retained. This balance was 2.91 and 3.76 g/24 hr (5.1 and 6.8% of intake) for cows 5 and 6, respectively.

The N-losses due to skin excretion and shed hair are estimated by BLAXTER (1959) to be 5.0 ± 0.5 g/kg metabolic body size. These losses are neglected as subtracting this value from the N retained, found experimently, the N-balance would still be slightly positive, approaching zero.

From these experiments it was seen that there was a close relationship between the N-balance and the digestible nitrogen intake (r = 0.9326). Similar results were obtained by ELLIOT—TOPPS (1963). The two sets of values obtained here were related by linear regression (Y = 3.4464 X — 70.9506, where X is the D.N. intake and Y the N-balance). Determining the suitable level of digestible crude protein (Fig. 1) for maintenance, which caused neither N-retention nor N-depletion from animal body tissue (Y equals zero), this would be 36.30 g D.C.P./100 kg L.W. This apparently low protein requirement was associated with low endogenous N-loss and high efficiency of N-utilization by the cattle at N-equilibrium.

Table 4

Effect of the level of dietary protein on some blood constituents

Protein levels, g/100 kg L.W.		Sample I			Sample II		
		T.P.	N.P.N.	Urea-N	T.P.	N.P.N.	Urea-N
Trial I (50 g)	$\overline{X}$	6.86	94.95	21.98	6.59	105.45	22.99
	±	0.63	17.73	3.79	1.64	13.43	5.44
Trial II (40 g)	$\overline{X}$	6.03	79.18	19.64	6.24	84.40	21.82
	±	1.98	20.37	5.74	1.00	27.80	5.36
Trial III (30 g)	$\overline{X}$	6.01	99.33	36.55	6.53	95.08	38.21
	±	0.31	15.38	4.09	0.82	13.02	4.07
Trial IV (37.5 g)	$\overline{X}$	5.55	66.10	19.11	5.69	68.27	18.20
	±	0.74	18.80	3.64	1.04	12.86	2.87

Note: Sample I was taken one month after the start of the trial and sample II was taken at the end of the trial.

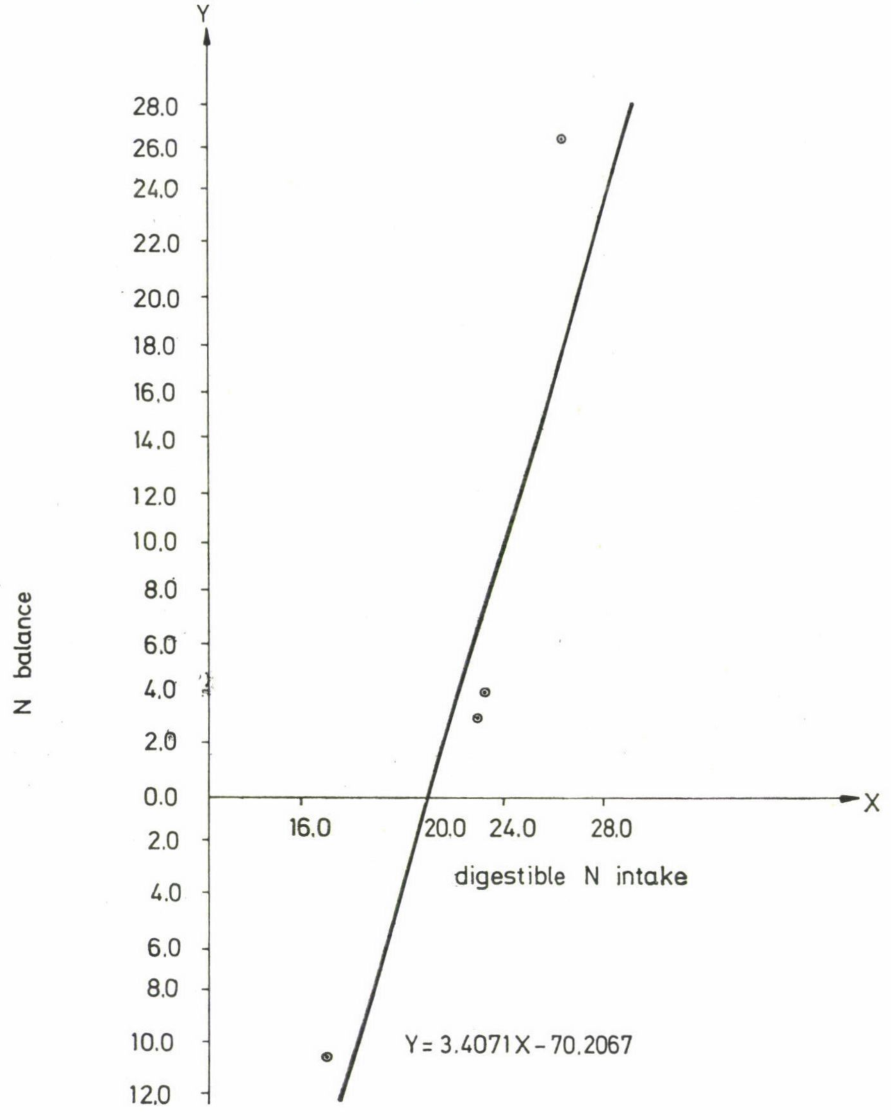


Fig. 1. Relationship between digestible N intake (X) and N balance (Y)

Blood composition. The effect of the intake of dietary protein upon the concentration of certain constituents of the blood serum are presented in Table 4. These results showed that the total protein in the blood serum increased slightly but not significantly with increasing D.C.P. in the ration. Similarly, HUBER—BOMAN (1966) and DARWISH (1973) found that the total serum protein was not significantly affected by the protein level of the diet.

The results in Table 4, also showed that the values of NPN and urea-N in the blood serum decreased with a decreasing level of D.C.P. intake, except those obtained at the 30 g level. These results are in agreement with those reported by HUBER—BOMAN (1966) and

DARWISH (1973). They showed that increasing the protein level of the diet significantly ($P < 0.01$) increased the NPN content of the blood.

On the other hand, the higher values observed with the lowest level of D.C.P. (30 g) may be attributed to body tissue catabolism, as confirmed by the loss in weight and the negative N-balance in trial III. It could be concluded from these data that blood urea-N and NPN may be used as an indicator of dietary protein intake.

Generally, it could be concluded that the protein level which would maintain a mature cow at constant body weight, equilibrium N-balance and minimum value of urea-N was practically 37.5 g D.C.P./100 kg L.W. This level is slightly higher than that found from N-balance trials, which was 36.3 g D.C.P. It would therefore be preferable to recommend this level as it would supply the necessary protein requirement with a margin of safety. This level represents 75% of the recommended allowance reported by GHONEIM (1958) for Egyptian cattle.

*

Prepared at the Department of Animal Production, Faculty of Agriculture, Assiut University, Assiut.

A. DARWISH, G. A. ABD EL-HAFIZ, S. MOSSELHY

References

A.O.A.C. (1960): Association of Official Agriculture Chemists (9th ed.) Official Methods of Analysis of the Association of Official Agricultural Chemists, Washington D.C.

BLAXTER, K. L. (1959): Scientific principles of feeding farm livestock, p. 21. London, Farmer and Stockbreeder Publications, Ltd.

DARWISH, A. H. (1973): Effect of dietary protein level on metabolism, milk yield and quality. Assiut, J. Agric. Sci., **4**, 115.

ELLIOTT, R. C.—TOPPS, J. H. (1963): Studies of protein requirements of ruminants. 1. Nitrogen balance trials on two breeds of African cattle given diets adequate in energy and low in protein. Brit. J. Nutr., **17**, 739.

GHONEIM, A. (1958): Animal Nutrition. 5th Ed. Anglo-Egyptian Library, Cairo (In Arabic).

HASHIZUME, T.—MORIMOTO, H.—MASUBICHI, T.—ABE, M.—HORII, S.—HAMADA, T.—TANAKA, K.—TAKAHASHI, S.—KAISHIO, Y.—ANBO, S. (1964): Studies on the feeding standard for dairy cattle. 11. Maintenance requirements of energy and protein for dairy cattle. Spec. Rep. nat. Inst. Anim. Ind., Japan, **2**, 7.

HUBER, J. T.—BOMAN, R. L. (1966): Effect of grain level and protein content of the grain for grazing cows on milk composition and yield, and certain blood and rumen constituents. J. Dairy Sci., **49**, 395.

MORIMOTO, H.—HASHIZUME, T.—MASUBUCHI, T.—SENDA, H.—HAYAKOWA, T.—KUDO, Y.—MIYAUCH, T.—TAKANO, K.—TOMINAGA, M.—MURAMATSU, M.—HARGU, T.—HANASAKA, S.—TOZUKA, H.—ISHII, S.—INUDO, Y.—MUKAI, A.—OKAMOTO, S. (1963): Studies on the feeding standard for dairy cattle. I. Maintenance requirements of dairy cattle by feeding experiments. Spec. Rep. nat. Inst., Anim. Ind., Japan, **34** (In Japanese).

PETROONKINA, A. M. (1961): Practical Biochemistry (3rd. ed.) Med. Giz., Leningrad (In Russian).

PRESTON, R. L. (1972): Protein requirements for growing and lactating ruminants. Proc. Univ. Nottingham Nutr. Conf. Feed Manuf. 6. H. Swan and D. Lewis, eds.

SNEDECOR, G. W. (1967): Statistical Methods. Iowa State Univ. Press, Ames, Iowa, USA.

ECOLOGICAL STUDIES OF SOIL MITES UNDER SOME TRUCK CROPS

Mites are known to cause extensive damage to vegetable crops (ATALLA—EL-ATROUZY (1971). Numerically mites are the dominant group of animals inhabiting soils. In the A.R.E., mites have become serious pests on different truck crops, as the favourable weather conditions have allowed a remarkable abundance of the mite fauna to survive throughout the

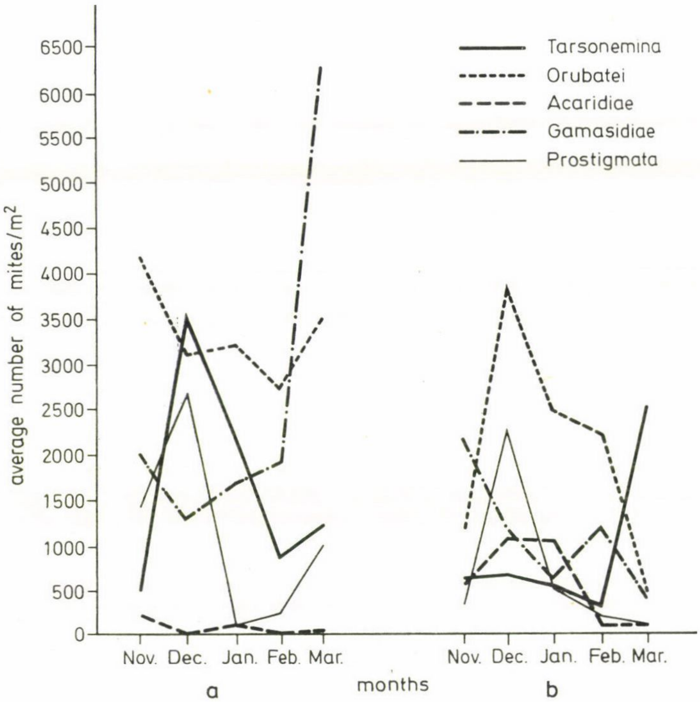


Fig. 1. Monthly variations (per m^2) of soil mites under some truck crops in 1977/78. *a)* Tomato. *b)* Pea

year. Therefore, it was found necessary to study the fauna of soil mites and seasonal variations in their population densities under certain vegetable crops in Menoufia Governorate, A.R.E.

The soil samples were taken with a $10 \times 10 \times 10$ cm iron sampler in randomised cores every 2 weeks during the study period November 1977 to March 1978. The samples represented the arable layer, from the surface down to a depth of 10 cm, from fields occupied with tomato and pea. The mites were carefully extracted from the soil using Berlese's Tullgren funnels, and identified with the aid of a stereoscopic binocular microscope.

The soil mites which were collected in association with tomato and pea belong to the suborders Mesostigmata, Trombidiformes and Sarcoptiformes (KRCZAL 1959, ABD EL-SHAHEED *et al.* 1972, GILYAROV—KRIVOLUTSKII 1975).

During the study period the population density of Tarsonemid mites under tomato was twice that under pea. The peak density in the tomato field was observed in December (3500 ind./m^2), while in the pea field the peak was in March (2500 ind./m^2) (Fig. 1a, b).

The maximum population density of Orubatids was recorded in November (4200 ind./m^2) under tomato and in December (3850 ind./m^2) under pea (Fig. 1a, b).

Acaridiae were observed in small numbers in the tomato field in November (200 ind./m^2) and in January (100 ind./m^2). These animals were not recorded at all in December, February and March. Under pea they were observed in remarkable abundance, which reached its peak in January (1100 ind./m^2).

The maximum number of Gamasid mites was observed under tomato in March (6400 ind./m^2), and in the pea field in November (2200 ind./m^2).

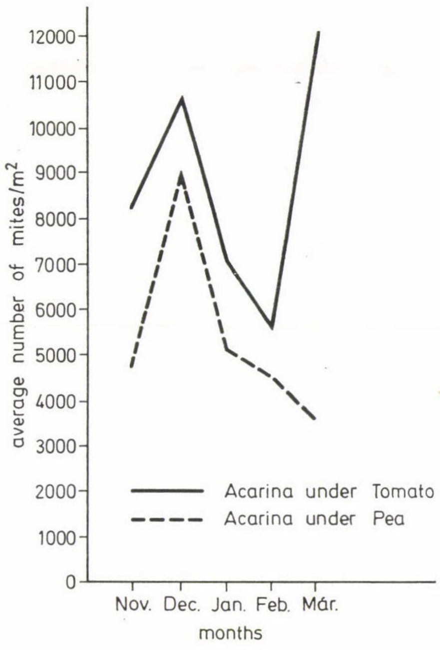


Fig. 2. Variations of soil mites under certain truck crops in 1977/78

Prostigmatid mites reached their peak density under both tomato and pea in December, with 2700 and 2250 ind./m^2 respectively.

Dhillon—Gibson (1962) reported that the population of Acarina fluctuated with time and marked differences occurred in the patterns of variation shown by different species. Our own results with Acarina are shown in Fig. 2.

*

Prepared at the Plant Protection Department, Faculty of Agriculture, University of Menoufia, Menoufia.

S. M. Abo Korah, A. A. Osman, G. I. Zohdy

References

Abd El-Shaheed, G. A.—Hammad, S. M.—El-Sawaf, S. K. (1972): Keys to mite species found on field crops in Alexandria region, U.A.R. Z. ang. Ent., **71**, 162—169.

Atalla, E. A. R.—El-Atrouzy, N. (1971): Survey of mites associated with vegetable crops in U.A.R. Agr. Res. Rev., Cairo, **49**, 116—117.

Dhillon, B. S.—Gibson, N. H. E. (1962): A study of the Acarina and Collembola of agricultural soils. 1. Numbers and distribution in undisturbed grassland, Pedobiologia, **1**, 189—209.

Gilyarov, M. C.—Krivolutskii, D. A.—Гиляров, М. С.—Криводуцкий, Д. А. (1975): Определитель обитающих в почве клещей (Sarcoptiformes). АН СССР зоол. ин-т, Москва. I—490.

Krczal, H. (1959): Systematik und Ökologie der Pyemotiden. In: Stammer, H. J. Beiträge zur Systematik und Ökologie mitteleuropäischer Acarina, **1/2**, 385—626.

MORPHOLOGICAL CHANGES IN SUNNHEMP VIRUS-INFECTED AND MORPHACTIN-TREATED PLANTS OF CROTALARIA JUNCEA LINN.

The crop plant *Crotalaria juncea* is cultivated for its great economic importance — as a green manure, to obtain fibre and as fodder. The present work deals with a critical comparative study of plants infected with sunnhemp virus and plants sprayed with morphactin (NATH—MUKERJI 1978).

Sunnhemp plants were grown in the departmental garden in order to study the effect of morphactin on the mycoflora of the leaves in the year 1977. The principle objective was to study whether the morphological variation brings out any change in the microbial population of the leaf surface or not, besides its usual effect in producing morphological changes (SCHNEIDER 1970).

In the following year (1978) it was interesting to note that most of the plants sown showed a close resemblance to the morphactin-sprayed plants. A detailed study of these plants and of morphactin-sprayed plants was carried out.

The 1978 crop, which showed a close resemblance to the morphactin-sprayed plants, was previously thought to be due to some residual effect of the morphactin sprayed in the previous year. But later, after critical analysis, it was confirmed that the plants were infected with sunnhemp mosaic virus, as reported earlier by SAHAMBI (1967), NARIANI—KARTHA (1970) and NIAZI *et al.* (1973). This virus showed typical phyllody symptoms. On comparing the characters of both types of plants it was observed that there is a close resemblance in the morphologically changed vegetative parts. These are as follows:

1. Shortening of the internodes.
2. Stimulation of axillary buds resulting in profuse branching.
3. Considerable reduction in leaf size.
4. Leaves become dark coloured and irregular and increase remarkably in number.
5. Stem becomes fleshy and hairy.

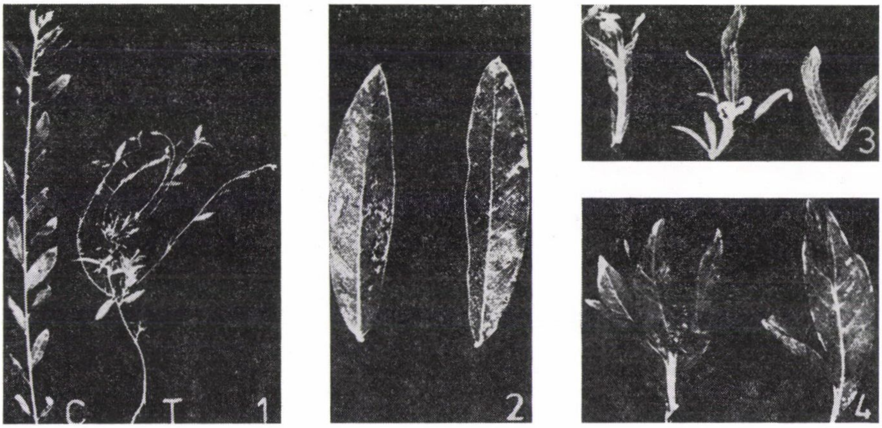
All these abnormalities in the vegetative parts in moth types of plants give a bushy appearance to the plant (Figs. 1, 5).

Regarding the floral parts, abnormalities are more acute in virus-infected plants as compared to morphactin plants (Figs. 7—9). The virus-infected plants show the following changes:

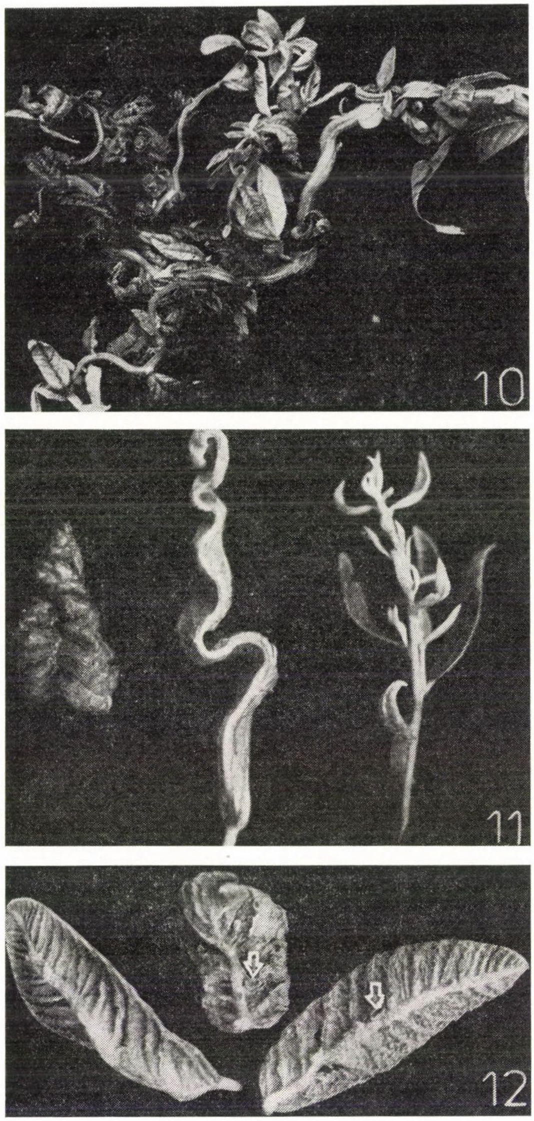
1. Flowers are formed excessively, but they are deformed.
2. Flowers are completely changed into vegetative structures.
3. Petals, sepals, stamens and carpels become green and leafy.
4. A number of branches arise from within the flowers at the axils of the leafy sepals giving a compact, abnormal appearance (Figs. 6, 9).

In addition, there are certain other abnormalities in the virus-infected plants (Figs. 10—12), e.g. appearance of pocket-like structure on the under surface of leaves (Fig. 12, arrow); the plants become highly twisted apically (Fig. 10). Some of the leaves become banded and crumpled (Fig. 11).

Phyllody of both the vegetative and floral parts was observed, which, in the case of nirus-infected plants, was more acute in the floral parts, i.e. there was profuse flowering and all the flowers changed into leafy structures. But in morphactin-treated plants flowering was vormal and significant changes occurred in the leaf structure and shape (Figs. 2—4).



Figs. 1—4. Showing abnormalities in morphactin-treated plants. 1. Control (C) and treated (T) plant. 2. Leaves from the control plants. 3, 4. Leaves from the morphactin-treated plants *Figs. 5—12.* Showing abnormalities in Sunnhemp Mosaic Virus-infected plants. 5. Control (C) and virus-infected (V) plant. 6. Plant showing axillary branching due to virus infection. 7. Control flower. 8, 9. Abnormal flowers of infected plants



10. Twisted appearance of apical part.
11. Crumpled and banded leaves. 12. Pocket-like structures on under surface of infected leaves (arrow)

Acknowledgements

Thanks are due to Dr T. K. Nariani of the Mycology and Plant Pathology Division, IARI, New Delhi, for suggestions. The senior author is also grateful to UGC for financial assitance. One of us (MM) is grateful to the Ministry of Home Affairs, Govt. of India, for financial help.

*

Prepared at the Mycology Laboratory, Department of Botany, University of Delhi, Delhi.

R. NATH, M. MATHUR, K. G. MUKERJI

References

NARIANI, T. K.—KARTHA, K. K. (1970): Behaviour of sunnhemp mosaic virus in sunnhemp *(C. juncea)* and tobacco (N.T. var. W.B.). Curr. Sci., **39**, 263.

NATH, R.—MUKERJI, K. G. (1981): Microbial ecology of the morphactin-treated leaves of *Crotalaria juncea*. Acta Agron. Hung. (in press).

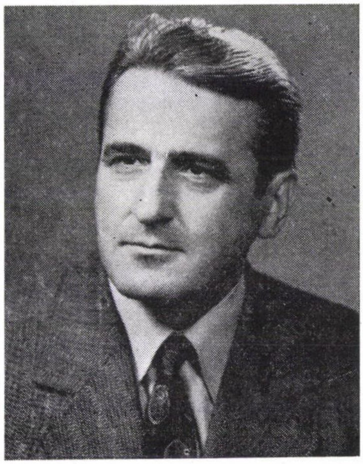
NIAZI, F. R.—CHANDRA, J. K.—PRAKASH, R. (1973): A new strain of tobacco mosaic virus infecting lumen Hemp. Ind. Phytopath., **1**, 5—121.

SAHAMBI, H. S. (1967): Studies on Sesamum phyllody virus with special reference to host range and relationship with its vector *Orosius albicinctus* distant. Ph. D. Thesis, IARI, New Delhi, India.

SCHNEIDER, G. (1970): Morphactins: Physiology and Performance. Ann. Rev. Pl. Physiol., **21**, 499—536.

Acta Agronomica Academiae Scientiarum Hungaricae, Tomus 29 (1–2), pp. 109–115 (1980)

"AS I SEE IT..."



QUESTION-MARKS AND CERTAINTIES – THE FUTURE OF AGRICULTURE IN HUNGARY*

It is a difficult but nevertheless thankful task to write about the future of agriculture in Hungary in the journal of the Hungarian Academy of Sciences. It is difficult, because the future can only be contemplated and examined using the rapidly changing present as a starting point and by extrapolating processes with which we are more or less familiar. The agricultural technology of the world, however, is just going through a period when it is gathering strength for the next stage of development. The task is a thankful one because the request shows that there is increasing interest from abroad in the results of Hungarian agriculture.

In the professional circles following the agriculture of Hungary from abroad the general opinion is, that in the 35 years since World War II it has developed almost more than it did in the whole of its previous history. This opinion is supported quantitatively by statistical data, and qualitatively by the obvious changes that have taken place in the social, economic and political life of the Hungarian village communities.

However, since Hungary is a small country, the results achieved must be compared to the possibilities available and to the international vanguard rather than to ourselves.

The extent to which the latest production methods are applied in Hungarian agriculture has substantially improved, while the forms of organization are suited to the applied technologies and render adequate relations with the processing industry and other industries possible; the system of material and technical supply and the training of specialists have been developed, and Hungarian agriculture also takes a satisfactory part in international economic relations. When evaluating the present situation it can be established that Hungary's backwardness compared to countries with a developed agriculture has considerably lessened, though it has not ceased to exist completely. A considerable improvement is, however, taking place in the application of the latest and most successful production methods. Since catching

* The manuscript was prepared in 1979.

up is not just a technical or technological problem, a knowledge of the present situation is particularly important. However, an evaluation of Hungarian agriculture is only possible if the international situation and the specific Hungarian conditions are taken into consideration. What are these?

1. By European standards Hungary has the highest percentage of land under agricultural cultivation (about 75%), coupled with a relatively low population density.
2. In Hungary the livestock has an unusual composition. The proportion of animals fed on grain fodder is high, 80%, which in itself is unparalleled.
3. At present Hungarian agriculture consists not only of large-scale, modern farms but also of older methods of farming, such as household plots and private farms.
4. Unlike many other countries which carry out monocultural production the agricultural production of Hungary covers almost the whole range of crops. This "whole range" increases the demands on industry.
5. Hungary is a country poor in materials and energy, where although agriculture is one of the big energy consumers, it is almost the only energy producer, apart from the mining industries.

I.

Facts from the recent past and the present

Looking back over a fairly long period it is found that since 1970 the annual average growth of agricultural production has been twice to two and a half times as much as it was in the decades preceding and following World War II. This process is clearly shown by the trends of per capita production in some of Hungary's particularly important crops.

International comparison of per capita production (kg) (1977)

Country	Wheat	Maize	Vegetables	Fruit
Hungary	499	577	215	236
Canada	843	185	63	27
France	329	162	123	212
USA	254	745	115	116
Austria	143	154	78	119
GFR	117	9	30	57
Italy	112	114	215	335
Denmark	119	—	40	32
Ireland	75	—	91	9
Holland	48	—	178	35

The data in the table also reveal that as regards per capita yield of wheat and maize Hungary is one of the biggest producers in the world. Of the two crops the climatic conditions of the country are more favourable for wheat. Most of Hungary falls within the northern part of the maize zone. For more than ten years production has exceeded the domestic requirements, and is doing so to an ever increasing extent. This is why Hungary, which was previously a net food importer, has, since the end of the sixties, become a steady exporter not only of vegetable foods but also of meat. Of the crop production records achieved last year two are particularly worth recording, namely the 42.8 q/ha yield of wheat and the more than 51 q/ha yield of maize. According to the report of the Central Statistical Office the total yield of maize was 12% higher than it was in 1977.

The total cereal production exceeded 13 million tons. The value of this yield — at 1976 prices — is 42 thousand million forints, which is 46%, i.e. nearly half, of the total value of national crop production. This means that these crops have a great influence on the whole economy of Hungary.

The 1978 results of livestock breeding also exceeded all previous achievements. Production rose in all branches and the number of livestock also increased on a national scale. The production value of livestock breeding approached 90 thousand million forints, which is 48—50% of the total production value of Hungarian agriculture. The slaughter pig production exceeded 11 million q, to be exact 1 million 134 thousand tons, and the production of poultry for slaughter reached nearly half a million tons. It can thus be said that for every Hungarian citizen more than 100 kg slaughter pig and 44 kg slaughter poultry were produced in 1978.

Of all the branches of food production livestock farming produces the highest value, as is shown by the fact that more than half of Hungary's exports, which amount to around 1 thousand million dollars, is made up of products of animal origin. Meat production is the branch that has exhibited the most spectacular development within the agriculture of Hungary. This rapid growth was sufficient to ensure the domestic meat supply and to increase the export returns at that time. The rapid growth required was achieved primarily by an increased utilization of high energy grain fodders. This partly explains the unusual livestock composition in Hungary, i.e. the high proportion of grain-fed animals. In connection with this, another record has been added to those mentioned above, though this should be evaluated somewhat differently: more than 10 million tons of grain fodder to a value of 44—45 thousand million Ft, were used in the country last year, which is only 1% more than in 1977. Thus, the efficiency of grain fodder utilization has improved, since the increase in grain fodder consumption, which is the "fuel consumption" of meat production, was lower than the increase in production itself.

Food prices have naturally risen substantially over the last twenty years. The price of pork, for example, has doubled compared to 1957. But for the same amount of pork the average Hungarian worker works 1 hour less today than he did in 1957, when the average monthly wage was about 1444 Ft (in 1977 the average wage exceeded 3250 Ft). In the same way, one-third as many working hours are needed now in order to buy 1 litre of cooking oil and half as many to buy 1 litre of milk and the list could be continued with other foods, not only the basic ones. Everything today is relatively cheaper; the housewife puts more into her shopping basket for 1 Ft than before.

I mentioned above that Hungary has an unusually high proportion of cultivated land. Nearly 75% of the total area of the country is utilized for agricultural production even today. This proportion is good by international standards, in spite of the fact that in the past three decades the agriculturally utilized area has been reduced by 700 thousand ha. Forests have been planted on half the area withdrawn from agriculture, mostly on lands of poorer quality, but partly for environmental protection purposes. The other half has been used for industrialization, communications and housing. It is a strange contradiction, but on many thousand hectares of land earlier used for agricultural production new towns, housing estates, industrial and mining plans, water works and roads, which are no less necessary, are now found. And it should be added that this process, the reduction of the agricultural area, has not stopped; it is still going on, though not so fast as in previous decades, and has already advanced farther than was planned for 1980. Unfortunately, this tendency, which is characteristic of the economically developing countries, has to be reckoned with as an objective situation in the future too.

In its agricultural policy the Hungarian government has taken numerous measures to stop or slow down the reduction of the agricultural area.

Thus, in the future agricultural areas can only be used for other purposes where this is unavoidable, and even then only on poor quality land. At the same time ways must be sought in which to extend agricultural production to cover new areas. Unfortunately, with the present extensive town planning policy there is little likelihood of this succeeding.

There is every justification for scientific investigations aimed at a relative extension of the production area by means of up-to-date soil nutrient management and amelioration and by planting the crop best suited to a given area. Significant results have already been achieved in this field. It is well known that in spite of the reduction in area mentioned above, Hungarian agriculture produces many times more than it did before. The rational utilization of the agricultural area is still not complete. People in Hungary are beginning to realize that the land is a national treasure which is irreplaceable.

The amount or proportion of cultivated land is only one of the components in the agricultural production potential. The other, no less important factor is the population density, particularly the density of the agricultural population.

According to official statistical data the number of agricultural earners in Hungary is now about 1 million, approximately 18% of the total number of active earners. Accordingly, every fifth person of working age is engaged in agricultural work.

The question is often raised, whether this proportion is high or low compared to other countries. The reader is no doubt familiar with the statistical data which show that this proportion is substantially lower in the economically developed countries, where only every tenth or twentieth worker is employed in agriculture. Such comparisons are designed to prove, whether openly or not, that Hungarian agriculture employs an unreasonably large labour force in a country where this labour force is badly needed in other fields too. Comments can also be heard to the effect that if Hungarian agriculture consists mostly of large farms and the mechanization of the different agricultural operations is at a high level, why is it that 17—18% of the active earners still work in agriculture, in contrast to countries with a highly developed agriculture where this proportion is 10% or less, despite the fact that in these countries the majority of farms are small, so the level of mechanization is obviously not as high. However, the international method of evaluation groups earners basically by organization and not by activity.

A consideration of the special nature of the Hungarian situation, as mentioned above, namely the outstandingly high proportion of agriculturally cultivated area and the relatively low population density, immediately clarifies this figure. The scope of activity on the Hungarian large-scale farms is not restricted only to agriculture. A considerable proportion of those working on the farms are involved in industrial work or servicing rather than agricultural activities, nevertheless, on an organizational basis, they figure as agricultural workers in the statistical data. About a quarter of them, however, cannot in fact be regarded as agricultural workers. So the proportion of agricultural earners can be put at about 14—15% at present. Although the components of this proportion can be compared with the international ratios, to judge it correctly other factors must also be taken into account. It is important to consider, for example, to what extent a given country exports or imports food. In Hungary the natural conditions are known to be favourable for agricultural production. There is a high proportion of arable land, orchards and vine-growing areas, and a considerable amount of food is exported. In England, on the other hand, arable land only takes up 29% of the agricultural area, and half the food requirements are obtained from other countries. It is obvious that the proportion of agricultural earners is necessarily different. This is why the area of arable land, garden and orchard per agricultural earner was 7.3 ha in Hungary in 1975. In this respect Hungary is in fourth place among the 18 countries with a developed agriculture. The national economic plans reckon with a decrease in the number of active earners to about 500 thousand by 1990, so that the proportion;of active earners working in agriculture will then be about 10%.

The multisectorial nature and the diversity of economic organization are interesting characteristics of the agriculture of Hungary, in others words, the fact that production is carried out in both state organizations, co-operatives and in the private sector. However, the socialist sector plays a decisive role in Hungary's agriculture, and this is divided into state and co-operative "organizations".

The sectorial division can be best characterized by the distribution of land, the most important means of production.

Agricultural area of the Hungarian People's Republic:	9 million	303	thousand	ha		100%
of which I. managed by the socialist sector:	8 ,,	747	,,	,,		94%
Within this						
— state or social property:	2 ,,	826	,,	,,	(30%)	
— managed and owned by co-operatives:	5 ,,	921	,,	,,	(64%)	
II. personal and private property:	—	556	,,	,,		6%
Within this						
— private farms	—	186	,,	,,	(2%)	
of which						
larger than 0.5 ha		128	,,	,,	(1.4%)	
smaller than 0.5 ha (6000 m²)		58	,,	,,	(0.6%)	
— supplementary farms		370	,,	,,	(4%)	

The multisectorial character of agriculture has a historical background. And so has the fact that instead of carrying on their activities separately the producers are linked to each other by a thousand threads. The "household plots" and "supplementary farms" are not really "private farms" at all; they work under socialist production conditions, with the assistance of the large-scale farms, using the latter's technical, technological and commercial background. This is definitely one of the factors responsible for the success achieved by Hungarian agriculture in the past, and will be so in the future too.

II.

Guarantees for the future

The national economy of Hungary, including the agriculture, will soon reach the end of the fifth five-year plan. Preparations and calculations for the sixth five-year plan are now in progress, so it is quite natural to review the endeavours we have made up to now and, after comparing them to the new problems life has raised, to decide which of them should be maintained and which changed.

The medium term objectives of Hungarian agriculture can be clearly formulated without going into details: for the eighties some fundamental questions, while gradually increasing quantitatively, have undergone qualitative changes, have become problems of quality and have suddenly assumed new aspects. An answer to these challenges must be forthcoming and if this is found there will be some hope that in two or three generations' time, when all the raw materials and fossilised energy sources of the country have been depleted, agriculture will be capable, by means of its material and intellectual exports, to provide those resources which the country will no longer be able to produce for itself. What are these challenges?

1. The reduction of the agricultural labour force.
2. The increasing economic sensitivity and growing energy and assets requirements of agricultural production.
3. The strengthening of protectionist tendencies in agricultural world production.

4. The contradiction between the uncertain vegetation period caused by the continental climate and the long vegetation period required for high yielding varieties.
5. The ecological capacity of our environment.

It should already be obvious at present whether challenges can be met, and if so, how. The answer is in fact quite clear; the long term development plans for agriculture and the food industry are based on the fact that the challenges can be met, and that the objectives can be well defined. Fundamentally, development can be expected in three spheres: in personnel training, in science and in the improvement of planning.

All the signs indicate that there is justification for expecting an increase in the standard of the research carried out at Hungarian universities and colleges, with the obvious consequence that the process of innovation will be speeded up. Here we are thinking not only of the agricultural institutions, although the improvement in the situation there is conspicuous, but also of the whole of higher education, since nearly every profession plays a role, directly or indirectly, in the huge machinery which serves Hungarian agriculture. And the acceleration of the innovation process is a key issue in the question of whether Hungarian agriculture and the food industry will be able to keep pace with the changes in market demands and compete on the international food markets with products whose composition and standard meet all the requirements.

On the other hand, the half-life of knowledge in agriculture is decreasing at a more and more noticeable rate. It is thus obvious that if agricultural experts are to be capable of adequately tackling the problems of the eighties they must be trained with different methods than those used even 15 years ago. The revolutionary changes that have occurred in agricultural techniques and technology must take place in the methods of training as well. The task facing the higher educational institutions is, however, more than simply supplying Hungarian agriculture and the food industry with politically, professionally and morally suitable candidates for leadership.

The future demands more than this. Greater emphasis should be laid during training on the development of personality, in order to produce open-minded experts who are able to deal with the human aspects of work and to keep order and discipline.

The rise in the standard of production brings us directly to the subject of applying scientific results in practice, and indirectly to the question of what help science is likely to give in solving the problems of the next decade. The question evidently has two sides: first, improvement in the reliability, i.e. efficiency of existing production processes and secondly, the introduction of new technologies which exist today on a laboratory scale at most.

The first range of ideas includes the production of new cold and drought tolerant, disease resistant varieties to increase the dependability of crop production; in livestock farming the development of breeds with better reproduction ability; furthermore, a partial change in agrometeorological or soil conditions and the introduction of high yielding plant varieties with a high protein content in general production. Another requirement in this context is the considerably better utilization of solar energy.

The second range of ideas includes possibilities thought by some to belong to the sphere of science fiction, such as controlling the sexual ratio, producing new breeds by gene surgery, or artificially inducing photosynthesis, etc. All these scientific possibilities are in the process of realization; some of them have already been solved on a laboratory scale.

Following personnel training and scientific advances, the third field where progress can be expected is in macro- and microeconomic planning work. This means, fundamentally, the better utilization of the possibilities offered by socialist land ownership and the socialist planned economy, and thereby the creation of a harmonious balance.

Proportionate development, the continuous improvement of management, an increase in the performance attained with the given labour force, land, materials and tools, and the realization of various objectives using the lowest possible investment are increasingly becoming the preconditions and sources of intensive, dynamic development in agriculture and the food industry. Consequently, proportionality must be aimed at much more systematically when integrating the vertical units in different branches, or groups of branches, of agriculture and in co-ordinating the activities of those branches of the national economy connected with agriculture, than has been done in the past.

Proportionate development must, of course, cover the whole verticum, yet special attention should be paid in the years to come to the relaxation of the tensions which exist between agriculture and food production in space, time, quality and capacity. When supplying food to the consumer and fulfilling the demands of light industry the agriculture of the coming years will be characterized not only by a quantitative growth, but also by an increase in the value of the components of the products, a higher degree of processing, a wider choice of products and more varied demands from the consumer. An increase in production is basically equivalent to a widening in the stocks available for export, which is impossible without a fundamental development and modernization of competitiveness. An improvement in the quality of the products and in the economic efficiency with which they are produced are becoming decisive factors on both the domestic and foreign markets.

It is evident that agricultural production and the food industry can only satisfy the domestic food requirements, and meet the demands of light industry, export and environmental protection, if the necessary materials, means and economic conditions, are available to them as an organic part of the national economy, acting in close co-operation with other branches according to their mutual interests. In agriculture, which is gradually becoming industrialized, and in the food industry too, the role and responsibility of those Hungarian industries which supply production tools, as well as that of foreign and domestic trade, will continue to grow.

Thus, in the agriculture of the eighties we shall witness a change in the proportions of the "national economy blocks". The ratio of the blocks formed by the food industry, industries manufacturing production tools and the servicing sector will grow compared to agriculture. So Hungary will come closer to the agriculturally developed countries in this respect too, as was pointed out at the conference of agricultural economists held in Dijon in 1978.

The exploitation of growing site potential in agriculture is of special importance, as it is in the mining industries. Different crops have definite climatic, soil and other requirements that can only be properly satisfied in certain regions or areas. The national economy and the co-operative and state farms are all equally interested in concentrating crops on optimum sites and increasing the division of labour between enterprises and areas.

Planning can and must be made more consistent in all fields of management. The planning of investment efficiency plays a decisive role in this, partly by counterbalancing rising costs. This means that more precise assessments than are made at present must be made of the prospective yield, the modifications in quality and index values and of the direct and indirect effects which cannot be expressed numerically, which can be expected from a given quantity and type of investments or from additional investments.

*

In Central Europe the concept of agricultural, peasant's work was once inseparable from that of immobility and lack of change. However, in the eighties and nineties this very agriculture will be the scene of the biological revolution which will follow the electronic revolution. This is the basis for our firm belief that there are many more certainties than question-marks in the future of agriculture.

P. Romány
Minister of Agriculture and Food of the
Hungarian People's Republic

Acta Agronomica Academiae Scientiarum Hungaricae, Tomus 29 (1—2), pp. 117—225 (1980)

FORUM

ARTIFICIAL FERTILIZATION

PARTICIPANTS

ÁCS, A.: *university professor* (Debrecen University of Agricultural Sciences, Department of Applied Farm Management, 4001 Debrecen, Böszörményi út 138.)

BARACS, J., *head of department* (Executive Committee of the Baranya County Council, Agricultural and Food Department, 7601 Pécs, Széchenyi tér 9.)

BAUER, F., *head of scientific department* (Vegetable Research Institute, 6000 Kecskemét, Kisfái 10.)

BEKE, F., *station manager* (Experimental Station of the Cereal Research Institute, 9761 Táplánszentkereszt)

BEKE, I., *head of plant production department* (Mid-Tisza State Farm, 5340 Kunhegyes, Szabadság tér 9—10.)

BUZÁS, I., *head of department* (Plant Protection and Agrochemistry Centre, 1118 Budapest, Budaörsi út 141—145.)

CSILLÉRY, M., *chief agronomist* ("Hunyadi" Co-operative Farm, 7018 Pusztaegres)

DEBRECZENI, B., *university professor* (Gödöllő University of Agricultural Sciences, Department of Agricultural Chemistry, 2103 Gödöllő)

DEBRECZENI, L., *lecturur* (Debrecen University of Agricultural Sciences, Department of Plant Production, 5540 Szarvas, Szabadság út 1—3.)

FAZEKAS, S., *university lecturer* (Semmelweis Medical University, 2nd Institute for Chemistry and Biochemistry, 1088 Budapest, Puskin u. 9.)

GYŐRI, D., *university professor* (Keszthely University of Agricultural Sciences, Department of Soil Science, 8361 Keszthely, Deák Ferenc u. 16.)

HARASZTI, E., *assistant professor, head of department* (University of Veterinary Sciences, Department of Plant Production, 1077 Budapest, Rottenbiller u. 50.)

HARMATI, I., *head of scientific department* (Cereal Research Institute, 6701 Szeged, Alsókikötősor 9.)

HELMECZI, B., *university professor* (Debrecen University of Agricultural Sciences, Department of Soil Science and Microbiology, 4001 Debrecen, Böszörményi út 138.)

HUSTI, M., *chief agronomist* (Babarc "Béke" Co-operative Farm, 7753 Szajk, Petőfi u. 163.)

KEMENESY, E., *retired university professor* (Keszthely University of Agricultural Sciences, Department of Plant Production, 8361 Keszthely, Deák Ferenc u. 16.)

KISS, A. S., *head of department* (Borsod Chemical Works, Agrochemical Department, 3700 Kazincbarcika)

KISS, Á., *scientific consultant* (Vegetable Research Institute, 6000 Kecskemét)

KOLTAY, Á., *senior researcher* (Agricultural Research Institute of the Hungarian Academy of Sciences, 2462 Martonvásár)

KOVÁTS, A., *university professor* (Keszthely University of Agricultural Sciences, Department of Plant Production, 8361 Keszthely, Deák Ferenc u. 16.)

KÜKEDI, E., *research worker* (Agricultural Research Institute of the Hungarian Academy of Sciences, 2462 Martonvásár)

LÁNG, G., *university professor* (Keszthely University of Agricultural Sciences, Department of Plant Production, 8361 Keszthely, Deák Ferenc u. 16.)

LŐRINCZ, J., *university professor* (Gödöllő University of Agricultural Sciences, Department of Agronomy and Plant Production, 2103 Gödöllő)

MIHÁLYFALVY, I., *scientific consultant* (Research Institute for Fruit Trees and Ornamentals, 1223 Budapest, Park u. 2.)

Molnár, F., *president* ("Jóreménység" Co-operative Farm, 8125 Sárkeresztúr)
Molnár, J., *assistant director* (Bácsalmás State Farm, 6430 Bácsalmás, Zrínyi u. 8.)
Nyéki, J., *university professor* (Keszthely University of Agricultural Sciences, Department of Plant Production, 8361 Keszthely, Deák Ferenc u. 16.)
Pais, I., *university professor* (University of Horticulture, Department of Chemistry, 1114 Budapest, Villányi út 29—31.)
Pál, Gy., *editor* (Acta Agron. Hung. Editorial Office, 2462 Martonvásár, P.O.B. 19.)
Pecznik, J., *university professor* (Gödöllő University of Agricultural Sciences, Department of Agricultural Chemistry, 2103 Gödöllő)
Petrasovits, I., *university professor* (Gödöllő University of Agricultural Sciences, Department of Water Management and Melioration, 2103 Gödöllő)
Petróczi, I., *university professor* (Gödöllő University of Agricultural Sciences, Department of Plant Protection, 2103 Gödöllő)
Pletser, J., *head of scientific group* (Agrometeorological Observatory of the Central Institute for Atmospheric Physics, 2462 Martonvásár)
Posgay, E., *head of scientific department* (Irrigation Research Institute, 5541 Szarvas, Szabadság út 2.)
Pozsár, B., *senior researcher* (Isotope Institute of the Hungarian Academy of Sciences, 1525 Budapest, Konkoly Thege út)
Rakonczay, Z., *president* (National Bureau for Environmental Protection and Nature Conservancy, 1121 Budapest, Költő u. 21.)
Romány, P., *minister* (Ministry of Food and Agriculture, 1055 Budapest, Kossuth L. tér 11.)
Semjén, I., *vice-president for production* ("Szovjet—Magyar Barátság" Co-operative Farm, 8151 Szabadbattyán)
Shmilliár, M., *senior researcher* (Experimental Station for Beet Production of the Research Institute for Sugar Production, 9463 Sopronhorpács)
Szabó, B., *vice-president for production* ("Lenin" Co-operative Farm, 5431 Tiszaföldvár)
Szalai, Gy., *director* (Research Institute of the Gödöllő University of Agricultural Sciences, 3356 Kompolt)
Szalay, S., *director* (Nuclear Research Institute of the Hungarian Academy of Sciences, 4001 Debrecen, Bem tér 18/c.)
Szeniczey, Cs., *president* ("Tata és Vidéke" General Consumption and Marketing Co-operative, 2891 Tata II, Bartók B. u. 9.)
Székessy-Hermann, V., *university professor* (Semmelweis Medical University, 2nd Institute for Chemistry and Biochemistry, 1088 Budapest, Puskin u. 9.)
Tarján, R., *director* (National Institute of Nutrition, 1097 Budapest, Gyáli út 3/a.)
Tompa, Gy., *head of department* (Szekszárd State Farm, Bureau for Socialist Co-operation in Maize Production, 7100 Szekszárd, Wine Production Works)
Tölgyesi, Gy., *legal consultant* (1172 Budapest, Kőtelek u. 12.)
Tukacs, O., *horticulturalist and environmental protection expert* (Agricultural Research Institute of the Hungarian Academy of Sciences, 2462 Martonvásár)
Tulcz, I., *vice-president for production* ("Győzelem" Co-operative Farm, 8136 Lajoskomárom)

*

Pál, Gy.: It is estimated that the world population will increase from 3.3 thousand million in 1960 to 4.4 thousand million by 1980 and will reach 6.4 thousand million in 2000. In your opinion, is a fast, intensive increase in the yields obtained on the existing agricultural areas the only way to satisfy the food requirements of the rapidly increasing world population, and of areas which are already insufficiently supplied with food, or is there any other solution to the world demand for food?

Ács, A.: I do not think we should accept a single solution to the question as being exclusively correct. It must be approached from various sides. For my part I will mention only a few points.

— The available arable area must be utilized better and more efficiently. Yield averages substantially higher than the present ones could be attained on the same acreage. Factors acting on the yield should be regarded and treated in a complex manner. Nutrients, water, melioration, variety and technical conditions should be considered together. The upper limit is represented by the solar energy, of which only a small proportion is utilized today.

— Another possibility is to produce foodstuffs from materials of other than agricultural origin. Alga cultures, for example, might be one of the sources.

— Synthetic materials may also help in solving the urgent food supply problems.

The world in general is relatively poor in protein, so special attention should be paid to protein production. Foodstuffs of animal origin represent one of the main sources. This raises the importance of fodder production.

BAUER, F.: Apart from increasing the yield on the existing agricultural areas there are considerable reserves available which could be used to cover the ever increasing food requirements of the world population which have not been sufficiently exploited so far. These include the abundant vegetation of the tropics, and the possibilities of alga production and industrial protein production.

BEKE, F.: The seas produce about eight times as much organic matter as the terrestrial plants. The dry lands utilize about 1—1.2 tons of carbon a year, which corresponds to some 5 tons of organic matter. Of this one-tenth may be human food or transformable nutrient. The annual carbon assimilation of the earth, including that of the seas, is 175 thousand million tons of carbon. This means about 400 thousand million tons of organic matter. Of this 7—8 thousand million tons of carbon is suitable for human nutrition. The annual carbon requirement of man is 0.54 tons. This is used for nutrition either directly or after transformation (animal, processing).

Thus, the Earth is capable of sustaining $8 \times 10^9 : 5.4 \times 10^{-1} = 15 \times 10^9$, i.e. 15 thousand million people.

BEKE, I.: The food supply can be ensured from the existing areas, for the foreseable future, through a rapid, intensive increase in yields.

Further possibilities of yield increase:

a) By extending the cultivation area the food supply of the rapidly increasing population could be improved.

b) The intensive cultivation of the oceans, by exploiting fish and algae, and the establishment of artificial islands offer further possibilities.

c) The industrial production of simple protein, and later, after 2000, that of complex proteins and carbohydrates. The synthetic production of certain vitamins and essential amino acids is already possible. The barriers facing this kind of industrial production at our present level of knowledge are not impassable, and their removal would mean boundless possibilities in supplying the world population with food.

BUZÁS, I.: A relatively easy calculation on the basis of the FAO surveys reveals that if agricultural yield results all over the world were raised to a level corresponding to a good medium at present, six times the present world population could be supplied with food from the existing agricultural area so that nobody would starve.

Considering that large areas suitable for agricultural production are still unexploited, and that in many countries the yields are artificially kept down to a relatively low level, I think that the world agriculture is theoretically capable of supplying 40 thousand million people with food.

This, however, is only a possibility. At present people are starving in many countries where the climate and the soil conditions are much more suitable for producing food crops than, for example, in Holland. This general backwardness is the consequence of the monoculture method of agricultural cultivation, inherited from colonial times. The liquidation of this backwardness is primarily a question of world policy rather than of agrochemistry. It is also a question of politics, in spite of the above, whether it will be easier and more expedient to concentrate on the development of agriculture in a given country or to introduce some other means of food production as yet unknown or known only in outline. (For example alga production on various culture media of industrial origin.)

DEBRECZENI, B.: Of the 6.4 thousand million people expected to live on the Earth at the turn of the century 77% will live in the present developing countries (Latin America, Africa, Asia) while the share of the developed countries (Europe, North America) in the total world population will fall from 30 to 23%. This shows that human reproduction is not uniform; the demographic explosion which causes serous problems occurs on the very areas where the level of economic development is low even now, so the living standard of the population is also less favourable. This population growth creates a demand for enormous amounts of food, which, in turn, calls for a still more intensive and more uniform development of world agriculture. Unlike the old and new propounders of

Malthusianism we believe that the development of means by which a rise in production can be ensured, e.g. chemization, can be substantially faster than the increase in the population. This requires, however, juster social systems and conditions, since the economic welfare of a country depends primarily on the country itself, with the assistance of more developed countries. The amount of food required to satisfy the requirements of the world population at the turn of the century can be produced on the existing agricultural areas. According to Peterburgski's calculations, if the yields in the whole world could be raised by means of fertilization to the level already attained, for example, by Holland, this would suffice to supply 28 thousand million people with food. Thus, to answer the question: with the fullest possible utilization of the present, and in some places new agricultural areas, and with simultaneous changes in the social structures of the developing countries, the food supply of the world population will be ensured in the next millenium too.

DEBRECZENI, I.: Economists and nutritional experts have been studying the relationship between the world population and the amount of agricultural goods produced for nearly two hundred years, starting with T. R. Malthus in 1798. The result is always the same: the amount of food is not sufficient for the human race, in some parts of the world millions are starving.

Yet, in spite of the cold numerical facts for the world, the situation in the 20th century, more exactly from 1930 to 1970, has in my opinion, improved. The yields of crops like wheat, rice, barley and maize, which serve directly or indirectly as human nutrition, have increased at a faster rate than the world population (Tables 1 and 2). In 1930 the world population was 2070 million, and over the next forty years the growth was 1.75-fold. During the same period the yield increased 2.42-fold in wheat, 3.40-fold in rice, 3.24-fold in barley and 2.60-fold in maize.

On the basis of numerical data on the growth of the world population and the total yield of major crops in the past fifty years there is no reason to worry about the future. Firstly, it is definitely possible to increase the total quantity of yield. Where there is a shortage of food owing to the low yields of field crops, but the soil is suitable for agricultural cultivation and the people can work in peace, the use of a simpler form of the technology developed in countries with efficient agricultural production may double the yield on areas covering tens of millions of hectares.

Besides the possibilities of increasing the total quantity of major food items produced in the world, the growth of the world population must also be objectively analysed. The ever increasing rate of growth should be regarded as a fact in itself. If the world population in 1930 is taken as 1.00, the figure at twelve-year intervals is: 1.10, 1.21, 1.44 and 1.75. In Europe, including Hungary, however, the rate over the last fifty years is lower. The population in 1970 compared to 1930 has increased in the world 1.75-fold, in Europe 1.27-fold and in Hungary 1.18-fold. This is the result of modern family planning, the details of which need not be given here. The results achieved by family planning, as one of the numerous measures aimed at supplying the public, are by no means negligible. The idea of family planning will probably be adopted and put into practice within a reasonable time even by those countries where it is not known as yet.

GYŐRI, D.: In my opinion the food supply of the population can and must be ensured up to 70—80% by an intensive increase in yields on the existing agricultural areas. Any other method can only be taken into consideration as a supplementary solution for the next 20—30 years.

The area suitable for agricultural production can only be increased moderately and with considerable additional investments, and difficulties are also caused by the fact that these lands are generally a long way from areas where the technical level is sufficiently high. Agricultural production is carried out at present on about 10% of the land area of the Earth. An increase in the arable area thus seems to be possible.

HARASZTI, E.: The ever increasing food requirements of the world population cannot be covered in the long run from the existing agricultural areas merely by a rapid and intensive increase in yields. A further possibility is offered by an improvement in the genetic potential of plants, and the evolution and commercial production of new high-yielding varieties and hybrids. But a further increase in yield can be attained by soil biology, ecological, cultivation and agrotechnical measures adjusted to the demands of the up-to-date varieties; by basing production on irrigation, mechanization and crop organization; and last but not least by efficient weed and pest control.

The biologists and plant physiologists are faced with an important task, since it is through their research that more will be known on the role and effectiveness of photosynthesis, and it may prove possible to increase the assimilating surfaces of living cells or the energy-binding capacity of plant pigments, and consequently increase the organic matter production of plants.

HARMATI, I.: The rapid and intensive growth of agricultural production will be possible for a long time to come all over the world. Thus it will be possible to supply the population with food without any great difficulty for many years in those parts of the world where the density and growth rate of the population are not too high and the agricultural area is not too small. In those parts of the world, on the other hand, where, owing to the high population density and the backwardness of the agriculture, there is already a shortage of food, and where, in addition, the population growth rate is also high, nutrition will cause more and more serious problems. I do not think it likely that the food supply of such areas can be permanently solved by imports. The problem might be put off by an intensive and systematic reduction in the birth-rate together with a substantial increase in agricultural production.

As the population increases, if this involves a reduction in the per capita food rations, food production will assume increasing importance and become a central issue. Starvation, and the question of survival, will no doubt force the human race to make enormous efforts. It is possible that, besides a manifold increase in the intensity of agricultural production and the introduction of food rationing, the shortage of food will also be lessened by artificial food products. Man will be compelled to utilize for agricultural production areas that have hardly been cultivated up till now, or not at all, such as deserts, alkali wastes and jungles. In order to increase the intensity of production, the light and solar energy and the water resources will have to be much better exploited than they are now. Attempts will be made to maximize the utilization of precipitation water so as to ensure consistently large yields. Through the extraordinary development of technology completely new production procedures will no doubt be elaborated, new types of food manufactured, etc. There are thus ample possibilities for increasing the volume of food production.

Besides the food supply, a serious problem will probably be caused by the rapid pollution of the environment, which is a concomitant of development. As industry progresses an increasing amount of contamination is produced, while agriculture uses larger and larger amounts of chemicals, which threaten the human race to an ever greater extent. The question may well be raised, however, whether the increasing utilization of chemicals is really the only way to make agricultural production more intensive.

HELMECZI, B.: Seeing the favourable effects of artificial fertilizers it was earlier thought by many people that the replacement of organic matter was totally unnecessary, while others simplified the problem in the following way: large doses of fertilizer equals large yields. According to the latter view there is practically no limit to the increase in yield and the utilization of fertilizers.

I have always fought against this extreme view, emphasizing that there is a limit to the amount of fertilizer which can be used. In this context I have often referred to Paracelsus' statement that every chemical substance can be toxic, and it is only the quantity applied which decides whether it is a poison or not. Although this statement did not refer to fertilizers but to chemical substances in general, it has never been disproved; on the contrary, many have confirmed it on the basis of experience. For my part I would only add that if all chemicals are either medicines or poisons, why should fertilizers, which are produced by chemical factories similar to (and often the same as) those which produce the most effective medicines, be an exception. I have always believed that fertilizers are the nutrients, or if you like, medicines, of the plant, but we do not know where the limit is, beyond which it is a poison. This limit must be found for the different crops, soil types, climatic conditions and economic and ecological considerations, and environmental protection must also be taken into account.

With a one-sided application of fertilizers, there may be a shift in the ratio of elements in the soil. Some may accumulate, others may decrease to a minimum, and yet others may be totally exhausted. After some time this disturbance in the balance may show up in the plant organism, and in the course of transformation the effect may be even stronger in animal (and human) organisms. The results of recent investigations have demonstrated that this hypothesis has already become a fact in certain cases.

Everybody knows that, as productive organisms, all cultivated plants, without exception, take up inorganic substances as nutrients. This is no doubt why it seemed obvious to many microbiologists and others that the higher plants are nourished with the help of microorganisms. Later a number of researchers proved that the higher plants also take up nutrients without the help of microorganisms (sterile cultures), and there is no reason to doubt them. But both statements are only partly true. It is obvious that provided inorganic nutrients are available, higher plants can take them up without the intervention of microorganisms, but they can only utilise organic substances after they have been decomposed by microorganisms. I think that the essential difference between the use of organic and inorganic fertilizer follows from this. Nitrogen, phosphorus and other nutrients bound in organic forms as stable resources of nutrient only become available to the plants under favourable soil conditions when dynamic microorganism activity makes this possible. Under such circumstances, with a favourable supply of organic matter the plant can take up the amount of nutrient it needs at any time. The situation is different in the case of artificial fertilization, when the soil contains large quantities of unstable nutrient resources at one time. This labile nutrient content does not make a uniform nutrient supply possible, so at the start, in the absence of a regulatory system, the plant may take up a larger amount of nutrient than is necessary, while later, in consequence of a considerable decrease in the quantity available (depletion, leaching) it will not be able to take up sufficient for its needs. In short, the uniform nutrient supply of plants through fertilization could only be ensured by a gradual application of fertilizers, which then becomes an economic question.

In my opinion the food supply of the population can be ensured by a rapid, intensive increase in yields on the existing agricultural areas (which amount to 2,500 million ha, 16% of the total area of the continents). This is confirmed by the following data: in the 1960s the annual calorie requirement of the world population was 2.7×10^{15} kcal/year, while the proportion of the production of the biosphere utilizable for this purpose was 2.4×10^{15} kcal/year, that is, it nearly covered the requirements. The fact that some two-thirds of the world population was undernourished then and that many people on the Earth are still starving today is quite a different matter. Two further remarks are called for here: with the progress of industry and the increase in urbanization and communications the agriculturally utilizable areas must be expected to decrease. At the same time, thinking in terms of the period after the turn of this century, our aim must be to explore and exploit further possibilities of increasing production to a still greater extent. I am thinking here of techniques such as the fixing of larger proportions of light energy; the increase in protein production using alga cultures; the fixation of larger proportions of nitrogen from the air by increasing the reproduction and nitrogen fixing ability of N-fixing bacteria living free in the soil, and by adapting the N-fixing bacteria living in symbiosis with papilionaceous plants to other cultivated plants. The use for practical purposes of the N-fixing ability of procariotic blue algae also belongs here. A really scientific and valuable way of utilising these would be to transfer their N-fixing ability to eucariotic plants, particularly to cultivated field crops. Today this may seem to be a utopistic idea, but it is by no means inconceivable considering that the higher plants lost their N-fixing ability in the course of evolution.

HUSTI, M.: In my opinion there is no problem in supplying the population of Hungary with food. Arable land occupies 54% of the country's territory, some 5 million hectares; bread grain, potatoes, the raw materials for cooking-oil and sugar manufacturing, and in part for the textile industry have to be produced on this area.

There is no possibility of extending the agricultural area in Hungary.

The gradual reduction in the arable area of the country is becoming an ever greater problem. The Hungarian government has attempted to check this process by taking various measures, but it cannot be stopped entirely as it is the natural consequence of industrial development, urbanization, etc.

The only way to produce more food in Hungary is to increase the yield averages per unit area.

For this reason the most important task in field crop production is to acquire the best possible knowledge of the biology of the cultivated plants, and to organize the factors that influence production into systems which best promote an increase in yield averages, never forgetting the economic aspects of the problem.

The various production systems meet these requirements. The maize production system was the first of all the field crops to achieve a resounding success. In addition to maize, production systems have been organized in Hungary for wheat, potato, sugar-beet, alfalfa, sunflower and other crops. In the future the wide introduction of production systems encompassing the whole production verticum will promote the joint development of agriculture and the food industry. They also offer ample opportunity for putting the results of scientific research into practice.

An almost revolutionary transformation of agricultural production is taking place before our eyes. This is a necessary process if food production is to keep abreast with the ever increasing growth rate of the world population.

An important task for the plant breeders is to make various plants better able to utilize solar energy. There are extremely wide possibilities in this field.

KISS, A. S.: The food supply of the rapidly growing world population can, in my opinion, be improved in the fwiollong ways:

a) Better exploitation of the potential productivity of the existing plant varieties through the development of cultural practices and chemization. At present, the potential productivity inherent in the varieties is exploited 70% in wheat, 58% in maize, 64% in sugar-beet and 45% in potato.

b) Development and introduction of new varieties with higher productivity.

c) Materials of industrial origin will primarily be of use as protein supplements in animal feeding. These include NPN (non protein nitrogen) and SCP (single cell protein).

NPN (carbamide, biuret, amino acids, ammonium salts) has so far only been used as protein supplement in feeding ruminants and in supplementing limiting amino acids. The use of carbamide and biuret should be increased. Biuret would be particularly worth introducing, as, unlike carbamide, its use does not involve the danger of toxication, and it can be manufactured just as "unrestrictedly" as carbamide. The conversion of biuret is also just as satisfactory as the conversion of carbamide, except that the development of the hydrolysing rumen flora is slower, so it must be fed for a longer period.

The industrial side of SCP synthesis has practically been solved, starting either from a carbohydrate or from a hydrocarbon base, but its practical application is still in the initial phase, if the experimental amounts can be regarded as a beginning at all. SCP is the nutrient or the feed of the future. The latter is emphasized because it will probably be used primarily for feeding purposes rather than for human consumption.

d) Raising the protein level by using bioactive substances. Nitrogen compounds sprayed onto the leaves of plants are partly transformed into proteins even after the plants have been harvested (survival activity). A larger quantity of nitrogen can be applied and faster transformation can be obtained if bioactive compounds which stimulate protein synthesis are added in ppm quantities simultaneously with the nitrogen compounds. Since the unnaturally increased protein content falls to the original level within a few days in the living plant, it is important that harvesting should follow the treatment as soon as possible, so that the elimination of nitrogen (protein) will not ensue. Large-scale experience of successful leaf protein increase has been obtained with a preparation named Plantprotam. In this way NPN compounds can be transformed into protein nitrogen, which can also be utilized by animals other than ruminants.

KISS, Á.: The food supply of the population will be ensured in 2000 in spite of the high rate of population increase (73 million a year). More productive, intensive plant varieties, intensive agrotechnics and the extension of the agricultural area (e.g. by making deserts, poor quality soils and highlands suitable for cultivation, constructing tall greehouses, etc.) will all have a role in this.

According to FAO data the total world cereal production area was 677 million ha in 1961/65 and 722 million ha in 1971/75, that is, it increased by 7%; the world cereal production was 14.60 q/ha in 1961/65 and 18.46 q/ha in 1971/75, which means a 26.7% yield increase in ten years. In the same period the world population increased by 30%, from 1400 to 1800 million.

KOLTAY, Á.: As expected by estimates made nearly two decades ago the population of the world exceeded 4 thousand million in 1976, and there is no reason to doubt that it will really reach 6.4 thousand million in 2000. Naturally, food production has also developed in the meantime, but by no means to the desired extent; world surveys show that approximately half the total population is, to put it mildly, undernourished at present. The primary task of the human race is to produce sufficient food to meet the increasing requirements. This can only be achieved if it is organized on a world scale.

The simplest way of developing food production is to increase the yields on the existing agricultural areas, but this is not sufficient in itself.

Of the most important cereals supplying mass food (including the fodder grain crops) the total yield harvested in 1976 on the 759 million ha cereal production area of the world was 1.48 thousand million tons. If the present European average could be attained on the whole cereal production area of the world, that would mean an annual surplus of 0.8 thousand million tons. Even if, at enormous intellectual and financial cost, these ideal conditions could be made possible by 2000, the situation would not change fundamentally, due to the population increase which will have occurred in the meantime. The per capita world average of cereals would be about 0.37 tons, as it is today. Really satisfactory nutrition, however, requires at least twice that much.

An almost inexhaustible further food production reserve is the cultivation of so far unexploited areas. The area cultivated on the Earth at present could be at least doubled and the new areas could be turned into valuable cultivation areas within a short time if full use were made of the possibilities offered by up-to-date varieties, machines, nutrient supply, plant protection and irrigation, financed by investment on a large scale.

Of course, even with a large-scale use of energy food production will be subject to yearly fluctuations. The uniform food supply of the world will be based on the accumulation of reserves and the preservation of various foodstuffs.

KOVÁTS, A.: I should like to start from the fact that there is a limited area of land on the Earth, and this includes a definite acreage of agriculturally cultivable areas. It is difficult to tell how much of the area unused at present can be taken under agricultural cultivation in the future. The possibilities are probably fairly limited. Thus, in producing plant products only the existing agricultural area can be counted on.

The yields harvested in different parts of the world vary greatly with the natural conditions and the standard of cultivation. Owing to the uneven distribution of food and the varying level of agricultural production 60% of the world population is already undernourished. It follows that even if the present population is to be supplied an increase in yields is needed, and it is primarily in the economic sphere that the better distribution of food must be solved. However, it cannot be concluded from the present situation that at the end of the century the existing agricultural areas will no longer be able to supply sufficient food for the increased world population. The solution lies in the constant increase of yield per unit area, i.e. the rising level of agricultural production. There are still unexploited possibilities in this field. I should like to mention as an example that in Hungary the yield averages for wheat and maize have more than doubled during the last twenty years due to the higher rate of fertilization, the cultivation of more intensive varieties, modern mechanization, and the raising of the general level of production.

The yield averages can no longer be increased by means of the resources of agriculture alone; the external resources are continually growing in importance. The development of agriculture is thus a function of industrial development, particularly of progress in the heavy and chemical industries. The growth of agricultural production in the developing countries is also only possible if it is backed up by the development of industry.

The inclusion of higher yielding varieties in commercial production, and the greater use of external resources in agricultural production, especially in the developing countries, are reserves that will be able to provide for the population of the world in the coming years.

KÜKEDI, E.: Owing to the rapid increase in the world population and in its demands, the food supply is already causing serious problems. Even today 60% of the inhabitants of the Earth receive a daily amount of food equivalent to less than 2200 calories, and 800 million people are on the verge of starvation. In spite of this there is hope that the food supply of the world population, which is expected to increase to 6.4 thousand million or so by the end of this century, will improve. The rapid, intensive growth of yield averages will undoubtedly play a decisive role in changing the present situation. Besides this, however, other factors will also contribute to the improvement of the food situation. Of all the possibilities available in this field, help can mainly be expected from the following: the extension of the agricultural area, the maximum exploitation of the possibilities of up-to-date plant protection, the rapid mechanization of agriculture in the developing countries, the development of irrigation, the regulation of rivers and other waters, the improvement of professional knowledge, the establishment of new advisory stations and the extension of the existing ones, the granting of preferential credits for the necessary investments, the industrial production of proteins, and last but not least the better exploitation of the nutrient resources of oceans, rivers and other waters.

There are real grounds for expecting an extension in the area. According to the relevant data compiled by the Food and Agriculture Organization of the United Nations (FAO) the arable area of the world could be increased by a further 0.4 thousand million ha. A rational reduction in the meadows, pastures and jungles could also increase the area of arable land. Thus, the present arable area, which amounts to about 1.3 thousand million ha, could be doubled without any particular difficulty. Area extension is possible first and foremost in the developing countries. In the industrially and agriculturally developed countries further arable land suitable for cultivation is hardly to be found. In exceptional cases, however, there might be new possibilities even here, as shown by the example of Holland, where useful areas have been gained from the Atlantic Ocean.

A further important factor in improving the food supply is represented by up-to-date plant protection. This could help in saving the food and fodder crops which are to be produced. According to Cramer's data (Pflanzenschutz-Nachrichten "Bayer" 1967) a yearly loss of 23.9% is caused in wheat alone by various pests and pathogens. Animal pests are responsible for 5%, diseases for 9.1% and weeds for 9.8% of the yield losses occurring in the world. The situation is made even more difficult by the uneven distribution of the losses. In the developed countries, for example, serious losses only occur in years when the weather conditions are highly favourable to the pests and pathogens, while in the developing countries the damage is very severe every year at present. The losses could be reduced substantially, by about fifty per cent, all over the world, if the possibilities offered by the complex system of plant protection were fully exploited.

A further important factor in improving food production is the rapid mechanization of agriculture, the advantages of which are proved by the example of the developed countries. Mechanization would help the developing countries to carry out the necessary operations in due time and good quality, and the release of draught power would also result in advantages.

The extension of the irrigation area is also an important factor in changing the food situation for the better. The possibilities thus offered are unexploited as yet. The example of Egypt shows that by utilizing the water of the Nile even the deserts can be made suitable for cultivation. And recent results attained by irrigation in the South-European countries testify that even Europe has hidden reserves in this field.

The regulation of rivers and other waterways, the construction of systems of dams and repairs to the existing ones would help to protect the food and fodder plants.

The development of irrigation and the construction of dams are, however, highly capital-intensive investments; and the overwhelming majority of the developing countries do not possess the financial resources necessary for large investments, so they are forced to rely on the assistance of developed countries. Besides preferential credits they need the professional guidance of the developed countries as well.

Although the developing countries have received help from the developed countries through preferential credits, professional training courses and the establishment of advisory service stations, they themselves can also do a great deal to improve the present unfavourable food situation by training and employing their own professional staffs and by improving their professional propaganda.

And last but not least, the increased exploitation of the food reserves in oceans, rivers, lakes and other waters can also be expected. This would ease the present shortage of protein. The extension of artificial fish breeding could also help to remedy the problems.

To sum up, it can be seen that reserves are still available for supplying the world population with food. By utilizing them not only can the present difficulties be overcome, but the food supply at the end of the century can also be improved.

LÁNG, G.: The ability of the Earth to sustain the human race is not boundless. The introduction of birth control on a world scale is therefore unavoidable. The effect of this, however, will only be felt in several decades' time, so the development potentials of food production must be fully exploited in the coming years. The scientific knowledge required to produce the quantity of agricultural goods necessary to supply with food the 6.4 thousand million people expected to live on the Earth in the year 2000 is already available, so what is primarily needed is the economic policy conditions for a fast rate of increase in production. Since it is mainly in the developing countries that food production needs to be substantially increased, enormous problems of cultural policy and education must be solved to overcome the hunger which already exists and is expected to worsen in the future.

LŐRINCZ, J.: The question is difficult to answer, because the area suitable for agricultural production in the world is only partly utilized. Apart from this, the fauna and the algae that can be produced in the seas are only utilized as sources of food to a very slight extent. Taking all this into consideration I think that production could be increased at a faster rate than the increase in the world population. The propagation of birth control and the realization of the necessity of family planning may further ease this problem, but this obviously requires the collaboration of the whole world.

MIHÁLYFALVI, I.: While on a world scale the per capita agricultural area is 1.07 ha, it is 0.65 ha in Hungary and even less in some Western European countries. In my opinion the food supply of the population can be ensured first by a rapid and intensive increase in yields (this is the cheaper solution), and secondly by putting further areas under agricultural cultivation. The crop obtained on the approx. 2407 million ha area of meadows and pastures of the world should be increased and more rationally utilized, so that the production area of fodder plants could be reduced to give place to more valuable food crops.

Finally, with the wider application of family planning, a decreasing rate of population growth can also be expected.

MOLNÁR, J.: The unbelievably rast growth rate of the world population and the volume of goods produced by agriculture are not in equilibrium even today. Hundreds of millions of people are starving and the number of undernourished is also high. There are definitely great reserves for food production, as shown by the fast rate of increase in food production in countries with developed agricultures, though examples of this can be found in Hungary too.

I am convinced that up to the end of this century the population of the world can be more or less adequately supplied with food from the areas under cultivation at present. I think that the varieties and production techniques used at present in more developed countries are suitable for this purpose, but they ought to be adapted to areas producing extremely low average yields. This task would require much more intensive international co-operation, more goodwill and financial means than can be expected with the present social, political and economic diversity of the world.

It would be feasible to raise the level of food production so as to be three or three and a half times as high as it is now by the turn of the century, but this is not likely to be achieved for the above reasons.

NYÉKI, J.: The fast increase in the world population sets food production enormous tasks. The demand for foodstuffs is not, however, proportionate to the growth of the population, as the increased rate of civilization involves a rapid increase in demand. While the growth rate of the population can be determined more or less precisely, it is difficult to calculate the rate of increase in demand. The demand for food will undoubtedly be about 45—50% higher than the rate of population growth, and it will manifest itself first in a quantitative, and later in a qualitative increase.

The farm-scale agricultural field production will be able to fulfil the requirements for a long time to come. This also expresses the fact that an adjustment in the structure of the farms may result in a better fulfilment of the demands, as is shown by the example of Hungarian agriculture.

Many further possibilites should, however, be mentioned in connection with this subject.

Recent investigations on the ecological use of land suggest that a closer co-operation between different countries would allow agricultural production to be specialized on an international scale. The considerably improved conditions of transportation also lead towards this solution; in the future each crop will probably be grown under the ecological conditions best suiting it. The exploitation of this possibility, which is closely related to social development, may produce a further substantial increase in food production.

An increase in areal intensity, the cultivation of more productive species and varieties and increased soil fertility will naturally continue to represent great possibilities for increasing the efficiency of food production.

PAIS, I.: It is practically inconceivable that the rapidly increasing population of the world should be adequately supplied with food without a fast and intensive increase in the yields on the existing agricultural areas. True, other possibilities do exist, such as the use of previously uncultivated areas (this possibility is very limited!), the production of protein type raw materials by processing algae, yeast cultures or plants so far not used for nutritional purposes, the increased exploitation of the ocean, etc., but in my opinion, these do not fundamentally change the situation.

PECZNIK, J.: Photosynthesis, the carbon dioxide assimilation of green plants, is the basic process of organic life on the Earth. The initial and final state of this process can be expressed by the following simple chemical equation:

$$6\ CO_2 + 6\ H_2O \xrightarrow{h\nu} C_6H_{12}O_6 + 6\ O_2 \quad G = 2850\ kJ$$

The carbohydrates formed during carbon dioxide assimilation make up the basic material of the other organic components of the plant organism, while the organic compounds synthesized by the plant are organic matter sources for all living organisms incapable of carbon dioxide assimilation. In order to be able to synthesize the compounds required to build up its organism the plant needs light energy, water, carbon dioxide and mineral salts: these are indispensable if a crop is to be produced. Thus, the production of the crop can also be expressed by an equation (assuming, naturally, the presence of a plant organism capable of assimilation, favourable temperature conditions, suitable cultural practices, etc.):

$$\text{Crop} = \text{Energy} + \text{Carbon dioxide} + \text{Water} + \text{Mineral salts}$$

It may perhaps be worth examining to what extent the basic factors necessary for producing a crop are available in Hungary, in other words, what the possibilities of crop production are from a chemical point of view.

Light energy is available practically unrestrictedly. We can reckon with 420 kJ/cm^2 solar energy a year in Hungary. Even if we only consider the 50% of this which is present during the growth season, this amount of energy would, according to the equation, be sufficient to produce 1300 ton/ha organic matter. However, the plants absorb only 50% of the light energy reaching their leaves, the rest is either transmitted or reflected; and in fact only 2.2% of the absorbed energy, i.e. 1.1% of the total radiated energy, is transformed by the leaves into chemical energy fixed in organic compounds; the rest of the energy absorbed is used mainly for the evaporation of water.

The average concentration of carbon dioxide in the air is 0.03%. The carbon dioxide requirement of our cultivated plants is about 200 kg/ha/day, but under favourable conditions the carbon dioxide uptake may be as much as 1000 kg. To provide the amount of carbon dioxide utilized by the leaves of the plants an air current of 4—5 million m^3/ha is necessary. The exchange of air is ensured by the wind and by downward and upward air currents. Apart from this, the air layers near the soil surface are enriched by carbon dioxide diffusing from the soil. This carbon dioxide is mostly the result of the life functions of microorganisms living in the soil. The effect on the yield of carbon dioxide diffusing from the soil is rather difficult to demonstrate experimentally. On the basis of theoretical considerations, however, it can nevertheless be stated that the organic matter content of the soil and the microbiological activity related to it do have some role in the carbon dioxide assimilation, and consequently in making the soil fertile. It is certainly a fact that the intensity of the carbon dioxide assimilation depends, among other things, on the CO_2 concentration of the air space in the environment of the plant.

Water, unlike solar energy and carbon dioxide, is only available in limited amounts. On average the plant has to evaporate 500 litre water to produce one kg dry matter. If the average annual precipitation of Hungary is taken as 500 mm, this is equivalent to 5000 m^3/ha water. This amount of water is sufficient to produce 10 tons of dry matter (organic matter). It must also be taken into consideration, however, that the amount of water evaporated by the plant during the production of a unit quantity of dry matter is smaller under favourable and larger under unfavourable conditions of nutrition. It has been proved in many fertilization experiments that if the soil is adequately supplied with nutrients and the nutritive elements are present in the proper physiological proportions, the value of the transpiration coefficient can be substantially reduced. It is largely due to this fact that in the Hungarian large-scale farms the yield fluctuation has become much lower since the introduction of intensive fertilization in spite of the fact that weather extremes obviously continue to occur. It can be assumed that apart from adequate mineral nutrition, the CO_2 supply has also had something to do with the favourable trend of the transpiration coefficient.

The mineral nutrient content of the soils in Hungary is relatively favourable; up to a depth of one and a half metres the soils contain an average of 20—30 ton/ha of the three major nutrients (N, P, K). The plants only extract a few thousandths of this quantity from the soil each year. The nutrients mentioned are, however, mostly unavailable to the plants. In the course of chemical and biological disintegration a fraction of the nutrients does become available from year to year, but this amount is usually so small that it does not make the development of large yields possible. Thus, it is definitely necessary to replace the nutrients extracted by the plants from year to year, or even to increase the nutrient level of the soil if large yields are to be obtained.

The oldest and most natural way of replacing the nutrients is by applying organic manure. In this respect, however, not only are the possibilities limited, but even in the most favourable case production could only be stabilized at a low level if we wished to solve nutrient replacement exclusively by organic manuring. In Hungarian agriculture there has been a favourable increase in the consumption of fertilizers lately. Some 4/5 of the nutrients are now supplied in the form of artificial fertilizers, and at least 50% of the increase in yields can be attributed to the higher rate of fertilization. In the future this ratio will shift even more in favour of fertilization.

In my opinion the food supply of the world population will be based for a long time to come on the carbon dioxide assimilation of autotrophic plants capable of photosynthesis. For this reason attempts must be made both in scientific research and in practical farming to increase the efficiency of this basic process. There are various ways of doing this (e.g. selection of plants which make better use of light energy, farm-scale production of unicellular organisms, carbon dioxide fertilization, application of plant metabolism regulators, etc.), but the short term results can primarily be expected from the intensive use of fertilizers and pesticides produced by the chemical industry. Other solutions (e.g. production of artificial food) cannot be seriously considered until the energy problems of the world are solved for good.

PETRASOVITS, I.: I think that the improvement of the world nutrition situation should be attempted simultaneously in more ways than one.

In the first place, yields can and must be increased on the existing agricultural areas by intensively developing production. In this work the new, higher yielding species and varieties represent the biological potential. They will only produce the desired result, however, if there is a simultaneous improvement in the natural water balance (water management, irrigation) and in the application of chemicals (fertilizers, pesticides).

This intensive type of production development must be combined with a sharp reduction in the present production losses (caused by pests, unfavourable weather conditions, harvesting, transportation, storage).

There are still great prospects for bringing further areas under cultivation, or for permanently utilizing areas which are only cultivated from time to time at present. For example, on large tropical and subtropical areas, which are in an unfavourable position from the point of view of food supply, two- and threefold production should be introduced. The main ecological precondition for this is water regulation.

There are great reserves for a substantial increase in food production in a wider utilization of water as the site of photosynthesis and organic matter transformation. For countries poor in water the establishment of artificial fish-ponds and water reservoirs, in other cases the lakes and inland seas, and last but not least the oceans are unexploited resources of intensive food production. In many parts of the world the introduction of organisms which are already known or the production of new aquatic plant and animal species and varieties may, by concentrating solar energy, achieve nearly the same importance as field crop production in the next century.

Nevertheless I think that traditional but intensified crop production will remain the main source of food production even in the next century, both in the field under controlled natural conditions, and in greenhouses under artificial conditions.

The world-scale realization of these possibilities depends on two major conditions: sufficient financial means and professional skill.

PETRÓCZI, I.: Through a rapid and intensive increase in yields the world population can be properly supplied with food in the coming decades. The fertility of the soil must be improved by up-to-date soil conservation, economical irrigation, inland water regulation and soil amelioration. It is important that the new up-to-date production systems and increased chemization should be introduced on state and co-operative farms with unfavourable site conditions, using differentiated melioration programmes. The processing andutilization of by-products will play an important role. In this respect we already have favourable experiences in the utilization of non-toxic microspores.

Pozsár, B.: According to the experience gained in the last decades, yield averages can be more effectively increased on the existing cultivation area than by including new areas (e.g. virgin lands) in agricultural production. Nevertheless, by means of subsoil irrigation in desert areas even more food could be produced, probably economically and with good yield averages. The biomass of warm seas is not sufficiently utilized as food at the moment; substantial progress is expected from an increase in refrigeration and canning capacities. Metabolite production by the chemical industry, which is expected to begin between 1980 and 2000, is also highly promising.

Rakonczay, Z.: A fast and intensive increase in yield on the existing agricultural areas will not, in my opinion, suffice to supply the population with food. This is, of course, one of the most obvious and perhaps simplest solutions. Apart from this, however, I think the following are very important:

a) The natural and artificial waters, including lakes and ponds, rivers and seas, are not made sufficient use of for the purpose of food production. The present situation is characterised by two features; one is that production in certain fields is very extensive that is, fish and other aquatic organisms suitable for nutrition are not farmed, only caught; the other is that exploitation is so ruthless that even the breeding stock is slowly being depleted.

I would therefore suggest that aquatic food production should be made more intensive and wasteful management should be prevented. This only applies to fish and other aquatic animals suitable for nutritional purposes. The situation is much worse with the aquatic plants, algae, etc. There seem to me to be vast unexploited possibilities in this field.

b) The food supply could be substantially improved if the sometimes intolerable wastage of food could be prevented. It is a well-known fact that some of the food produced is lost during harvesting, storage and marketing. If harvesting were better organized and carried out at the right time, and if the produce were stored and transported in a more competent manner, these losses could be substantially reduced. The wastage caused by consumers is equally inadmissible. In public catering and in households large amounts of food, produced at a high cost, are lost.

The amount of food which goes to waste in public catering, e.g. in students' hostels, restaurants, army barracks and holiday homes, could be considerably reduced if portioning were carried out in a more reasonable manner. In most places the portions are all the same size. Heavy eaters who have worked up a good appetite are given the same amount as poor eaters who are not really hungry. In most holiday hostels a 3-year-old child is given just as much as a miner of 40. In such places a variety of portions should be introduced, e.g. small, medium and large portions. Where a number of people eat at the same table portioning should be replaced by a method of dishing up whereby everyone takes as much as they want and what is left over can be used again. This is similar to the so-called Swedish system used in many places. More or less the same applied to drinks. In Hungary, for instance wine is often only available in 0.7 or 1 litre bottles, and beer in half-litre bottles.

The wastage occurring in households can only be stopped by price regulations and education. People are generally careless with food obtained at a price lower than what it is really worth. So almost all subsidized products cause an indirect wastage of foodstuffs.

The squandering of bread is a well-known fact in Hungary. Calculations made a few years ago showed that the amount of bread thrown out was equal to that produced by 6 large state farms.

Apart from price regulations, intensive educational propaganda and respect for each other's work are also required here. In certain cases the wastage in households could also be prevented by proper portioning and by correcting bad habits.

In some countries it is quite natural for people to buy 100—150 g raw meat. In Hungary less than 1/2 kg meat is not usually bought. In a similar way, particularly in villages, people do not buy 200—250 g bread but a whole loaf, which generally weighs 2 kg.

People do not squander foodstuffs and drinks which are sold at prices equal to or higher than their respective values. They do not throw out half a salami or 2 dl cognac, but half a loaf of bread or half a bottle of beer are often wasted.

ROMÁNY, P.: There are very few complex problems for which a single concrete method would provide a satisfactory solution, and this is particularly true of the future of world nutrition.

Today every researcher of the future tries to study the world food supply as an integral part of the development model for the world economy; some of these models are pessimistic, others optimistic about the future. One of the latter, the Leontief model, demonstrates, for example, that to satisfy the requirements of the year 2000 the productivity of the earth must be tripled in the developing, and doubled in the developed countries. Cereal production needs an annual increase of 3.5% to reach a volume of 3,471 million tons (compared to 1,217 million at present), which means a growth rate higher than that expected in the world population.

This target is so tight that it is unlikely to be achieved simply by a rapid, intensive increase in yields, especially if it proves impossible to check the slow, but seemingly irresistible reduction in the agricultural area (town-planning and erosion in developed countries and alkalization and the encroachments of the desert in developing countries). Although new agrotechnical methods and the application of pesticides and fertilizers have doubled cereal yield averages over the last twenty years, this has not been without effect on the structure of the soil.

Thus it will not be possible to solve the nutrition problems of the world population with the present range of foods, just as the housing problems of millions of people all over the world cannot be alleviated by millions of family houses, but by blocks of houses built on housing estates using industrial methods. The yield averages of the species and varieties known today cannot be increased boundlessly. The solution undoubtedly lies in alternative sources of food, in including new plant varieties and animal breeds in food production, in utilizing the full range of food industry by-products, which so far have hardly been exploited, and finally, though perhaps only in the distant future, in acquiring better knowledge of the microbiological processes with a view to artificial photosynthesis. In the final analysis, everything depends on the race for energy: on whether or not sufficient cheap energy will be available by the time fossilised energy carriers are depleted.

If not, something I heard the other day on the radio will come about: if at some stage we have to do without fertilizers and pesticides, life will not come to a halt; but it will mean lowering our requirements and narrowing the choice of foods to comply with an 18 q/ha wheat yield level — and facing everything this involves.

SHMILLIÁR, M.: With proper care and circumspection the food supply of the ever increasing world population can, in my opinion, be ensured up to the turn of the century by the development of the traditional production methods, notwithstanding the fact that part of the human race is already undernourished. Great reserves are hidden in agricultural production itself, in the maximum possible exploitation of the potential productivity of animal breeds and plant varieties. It may be assumed that the research centres engaged in breeding will further increase this potential by developing new breeds and varieties. The new breeds and varieties will probably only be able to display to the full their characteristics and increase their yields with an intensive nutrient supply. Fertilizer manufacturing must be increased and the production of combined fertilizers further improved. Provided they are sufficiently rich in nutrients, the areas now under agricultural cultivation could be better utilized than they are today. But with a view to further progress intensive research aimed at detecting new sources of nutrient must be started at once. Some ideas, which seem fantastic at present, have been raised already, e.g. greenhouses with more than one storey where a continuous production of vegetables is carried on in culture fluids. Great attention should be paid to the preservation of food products in order to facilitate the processes of storage, distribution and transportation and make them economically more efficient.

SZALAY, S.: It would be an oversimplification to regard the food production and consumption of the whole world as a single threatened balance, in which case production should naturally be increased and the growth rate of the population decreased, with the emphasis on the latter. The question is rather which of these should be carried out where and how? To put the problem in a more concrete form: the developed countries attain outstanding results and even produce an excess of food and consumption goods, while the growth rate of the population has substantially decreased. The underdeveloped and developing countries, on the other hand, fall behind as regards production, but their population growth is disproportionately high. It would be unreal to hope to solve the serious problems of these latter countries by further increasing the food surpluses in one half of the world and handing them over to the starving half. Experience shows that even in the case of unexpected disasters (flood, drought, etc.) where the action is ethically undisputable immediate aid does not usually reach those most in need of it, because the areas concerned are undeveloped and unorganized politically and socially as well, and the unselfish aid disappears on the black market to increase the wealth of corrupt, despotic leaders.

In the long run they have to be supplied with knowledge rather than with food, to remedy backwardness, increase productivity and decrease the growth of the population. Starving peoples must learn to produce on their own areas all the food and other goods that they and their future children require. It is the moral responsibility of the developed nations to help them to learn to do this. This solution leads to a more intensive exploitation of areas which up till now have been used for production incorrectly, and also to the utilization of further areas, all in the starving countries themselves.

In the underdeveloped or developing countries the shortage of food is caused in most cases by a general lack of knowledge rather than the lack of areas suitable for production. Untenable religious or mystic beliefs, superstitions and obsolete social structures which obstruct production are a great hindrance to development and at the same time increase the growth of the population. It is necessary for the producer not only to possess the knowledge indispensable for intensive production, but also to have an interest in checking his own reproduction. In an illiterate rural family the children represent an almost free labour force from early youth, or from an economic point of view, profitable assets and old-age insurance. In a developed society children have to be edueated and clothed at least until they approach maturity, when they leave the family and become independent workers; therefore the child is an unselfish, one-sided obligation assumed by the parents, in which they have to keep within bounds.

"Knowledge is power." The extension of knowledge undoubtedly enables people in want to exploit their own natural resources, energy carriers, production areas and other natural endowments to the optimum. To sum up, their problem will be solved in the long run by a large scale supply of knowledge rather than by emergency food aid offered by the developed countries. The shortage of food is the consequence of a shortage of knowledge !

In fact, even in the most developed countries there are hidden reserves which are not sufficiently exploited as yet. Modest investigations carried out by myself and my co-workers in recent years have revealed symptoms of microelement deficiency on peaty areas. With the help of this knowledge peaty soils covering 100 million hectares of the northern hemisphere could be better utilized than they are at present. Unfortanately, the overwhelming majority of peaty soils are found in developed countries in the temperate and cooler zones where no shortage of food occurs.

SZENICZEY, CS.: No doubt futurologists too are well aware of the fact that for various political' economic, social, etc. reasons a considerable part of the area suitable for agricultural use in the world is not under cultivation. And intensive agricultural production is conducted on only a fraction of the cultivated area. In my opinion this fact offers vast possibilities for food production in the long run.

The value of land and the status of agricultural work are likely to rise rapidly.

The difficulties of food supply involved with the rapid growth of the population may really become critical in economically underdeveloped, insolvent countries. Large-scale possibilities of solving the problem of public food supply in these countries are unlikely to be put into practice for well-known reasons. Without social changes there is no hope here of a solution.

SZÉKESSY-HERMANN, V.—FAZEKAS, S.: Amidst the food supply difficulties caused by the large growth in the population envisaged by the estimates, which is already making itself felt today, it would be a mistake not to pay attention to two points: *a)* the sudden increase in the population growth does not affect the whole world uniformly; today it chiefly affects the backward countries which have many hidden resources, i.e. the peoples of the so-called third world; *b)* the doubling of the population expected in the near future means not only the doubling of the number of consumers but also a substantial increase in the valuable human labour force.

Today, when justifying the establishment of an industrial background for agriculture it is very common to refer to the decreasing labour force per unit area available for agriculture. This argument is used even when those who elaborate the system are not themselves fully convinced of the harmlessness or economic efficiency of the large-scale operations planned or already in use. It would thus be a great mistake, when planning a production system capable of covering the increased food requirements of the world population, if the changes occurring in the distribution of the labour force and of production means in consequence of the population increase were left out of consideration. The Earth certainly has enormous reserves of land, particularly areas which, owing to their scattered nature and their situation, could mainly be cultivated by smaller communities. It is an increase in the intellectual level and professional knowledge of the population rather than the strengthening of the industrial background that will primarily determine the efficiency of cultivation, though naturally the most important basic materials and hand tools required for crop production and livestock farming must also be supplied. The homeplot and small farm production in Hungary, which produces about 30% of the food supply for the population, is somewhat different, but nevertheless illustrates the potential latent in small farms.

In order to make the agricultural utilization of human labour more efficient the first step should be, to abandon the fashionable view, based mainly on the principle of profitability, according to which only industrial activity is worthy of the working man. In actual fact, the excessive use of materials (chemicals) and means (energy) of industrial origin in agriculture, particularly when it is not coupled with competence, may threaten the health of man to a greater extent, both directly and indirectly (environmental pollution), than "unspoiled" agricultural work does.

TARJÁN, R.: Even using various methods of producing intensive yield increases it will only be possible to supply the continually increasing world population with an adequate quantity of foodstuffs to a certain extent.

Considering the geographical distribution of agricultural research (mostly in the United States of America and Europe, that is, in the northern hemisphere) as well as its objectives and results, I think that even the experience of history ought to warn us experts from industrially developed countries against trying to propagate the methods which have worked well under our social and production conditions to other parts of the world. In most of the industrially developed countries scientifically based chemical soil conservation, which is constantly being improved, has yielded remarkable results, and will probably continue to do so in the future. It is not certain, however, that under soil, climatic and social conditions differing from those in the northern hemisphere this is the only or the most feasible way. The increasing volume and range of chemicals used in agriculture already involves side-effects which are undesirable from the point of view of health and environmental protection. The prospect of spreading these side-effects all over the world should at least make the experts stop and think.

If land not currently used for agricultural production were made fertile (using soil cultivation methods adapted to local conditions) this would probably improve the situation of the starving half of the human race. In various fields of research, however, the local tasks must be determined in advance.

In my opinion the question of how the cultivated areas are utilised should also be gradually revised. On the cultivated areas, though the proportions vary, some human food, but mostly fodder crops are produced at present. A shift in the proportions in favour of human foodstuffs would most likely result in a faster and greater increase in food production than the extension of the cultivation area. Attempts should be made to solve the problems of animal feeding by intensive development in the chemical and biological industries (monocell-culture proteins, fodder yeast, etc.). More intensive research on soilless plant cultures (e.g. aquicultures) would also be desirable.

TOMPA, GY.: Parallel with the increase in the world population, the food requirements also increase, not only quantitatively but qualitatively too.

The basic task of agricultural production is to ensure a smooth supply of food so that even those areas and peoples which are deficiently provided for at present will receive a better food supply in the future.

The area of agricultural production is limited and is being decreased even more by industrialization and urbanization; it is thus evident that the solution for a long time to come depends on ways in which yields can be permanently increased.

The possibilities for increasing agricultural yields are far from being exhausted; in my opinion the present level of production is not more than 35—40% of that expected by the end of this century. As proved by the example of Hungary, where the yields of wheat and maize have been doubled in barely twenty years (and even this time could have been shortened), the yields of all major crops could be increased.

The quantity of agricultural products generally varies from year to year. In favourable years the crop production yields are considerably higher than in unfavourable ones. Unfortunately, it often happens that a considerable proportion of the yield surplus is lost because the processing and preserving industries cannot keep abreast with the agricultural production for lack of sufficient capacity. Yet preserving is one of the most important conditions for forming reserves which will be able to satisfy the ever increasing demands for a long time to come.

The next period of agricultural production, which in my opinion means a period far beyond the end of this century, will be characterized by an increasing amount of industrialization. Land will become an "industrial plant" in which the raw materials of foodstuffs are produced; and these raw materials, processed in the form of various concentrates, and probably enriched with a number of vitally important, synthetically produced additives, will be able to satisfy the nutrition requirements of the ever increasing world population.

TULCZ, I.: Besides an intensive growth in yields on the existing agricultural areas the utilization of other food resources will also be needed, in my opinion, if the world population is to be supplied with food.

There are still considerable areas suitable for agricultural cultivation in the world which have not been sufficiently exploited so far. I am thinking particularly of the fact that in Hungary, where agriculture is considered to be fairly well developed on a world standard, large areas are still not adequately utilized.

In my opinion science is likely to make great progress in biology in the next few decades, and this too should promote the development of food production to an extent unforeseeable at present.

The exploitation of the protein and other nutrient resources of the oceans also offers wide possibilities.

I believe that the synthetic production of basic foodstuffs will gain ground in the coming decades and that this will also contribute to human nutrition.

*

PÁL, GY.: **At a moderate estimate one ton of mixed fertilizer active agent makes it possible to attain an average 10 tons surplus output of basic foodstuffs. With a further increase in the rate of fertilization the volume of yield shows a linear growth up to a certain limiting amount of fertilizer. Do you think the amount of fertilizer should only be increased as long as it is profitable, or should it be increased beyond the optimum in order to be quite of ensuring the food supply of the population?**

ÁCS, A.: The world population must be supplied with the necessary foodstuffs. This is the basic attitude that cannot be altered by any strict considerations of "profitability". People live on food, and not on profit. But the question should not be put in this way at all. Profitability is not an absolute. The same amount of fertilizer will produce different results depending on other factors. In some crops and under certain conditions 10 q active agent may be the optimum rate of fertilization, while in other cases twice as much may be needed.

BARACS, J.: The question should be divided in two parts, one of which concerns economic efficiency, while the other goes beyond this limit, being a problem on a world scale.

Under the present farming conditions, when the farms, mostly in agreement with the government conceptions, have shaped their production patterns themselves, economic efficiency plays a leading role in the agrotechnics, including fertilizer utilization, required for production. In my opinion the consumption of fertilizers in most farms approaches the optimum level, particularly in the major branches of crop production (wheat, maize, sugar-beet, etc.), yet there are still some branches where it could be increased further. The amount of fertilizer applied to fodder crops, particularly to meadows and pastures, could be increased considerably. The present fertilizer utilization in wheat and maize, about 400 kg/ha active agent, is nearly optimum. As new techniques are developed and new varieties are introduced there is, of course, a possibility of increasing the amount of fertilizer used in these crops as well. However, in meadow and pasture farming two or three times as much fertilizer as that used at present would be required to reach the optimum.

It is reasonable to increase the rate of fertilization as long as it is still accompanied by a proportionate increase in yield per unit area. Fertilizer is naturally only one of the factors in the increase in production, and must therefore be combined with other yield-increasing factors. Experience has shown that an increase in the rate of fertilization beyond a certain limit is not economical, and occasionally may even cause a depression in yield.

The food supply of the population on a world scale is not possible with the present production systems and state subsidization. Under Hungarian conditions it would require a stricter pattern of farming, a higher level of state subsidization, and possibly financial support from world organizations. The farms cannot do it alone.

Bauer, F.: In my opinion the rate of fertilization should be increased only as long as it is economical, including a reasonable surplus nutrition to ensure yield stability. Any fertilizer produced in excess of this should best be sold to countries where it can be more efficiently used, so that in exchange products can be bought which are of higher value than the yield increase which would be attained by the uneconomical use of fertilizers at home.

Beke, F.: The increase in fertilizer rates should also be considered from the point of view of the national economy. Production requires a great deal of energy and therefore a constant rise in price must be reckoned with. The economic efficiency is determined by the ratio of product and fertilizer prices. In my opinion at both farm and national economic level the maximum dose is always controlled by the production costs, as well as by the fact that yields follow a saturation or logistic curve, not a linear one. Beyond a certain limit the yield increase is very slight, or the yield may even begin to decline (at about 350—500 kg active agent under the present conditions).

Beke, I.: The subsistence level must be ensured even if it can only be attained by means of uneconomical investments. Once the subsistence level is ensured, the rate of fertilization must not be increased beyond the optimum.

Buzás, I.: Recently there has been a tendency to simplify the concept of "optimum rate of fertilization" by speaking of a "profitable rate of fertilization". However, it is not simply the prices of agricultural produce and fertilizers that determine what the optimum is. This is just one special case of the potential optima, when the limiting factor at a given commodity price is the price of fertilizer, and at a given fertilizer price it is the price of the produce. As a matter of fact, in order to be able to speak of this kind of optimum at all within a given country many things have to be assumed. It must be assumed that an unlimited amount of fertilizer is available, that the price of the product will not change no matter how much is produced, that the produce in question is not in short supply, that the size of the area is not limited, etc.

It is easy to see that when the quantity of fertilizer is the limiting factor and there is a shortage of the given agricultural produce, then it is no longer the "profitable rate of fertilization" which will be optimum, but the rate of fertilization with which the largest yield can be obtained per unit amount of fertilizer active agent. By varying the limiting factors numerous other optima can be produced.

It is assumed in the question that if there is a certain increase in the world population a shortage of food may occur. Since industrial production can be increased in a practically unlimited manner, the amount of fertilizer should not be regarded as a limiting factor. The size of the area under agricultural cultivation at a given time is, on the other hand, a limiting factor. It is obvious that in this case the optimum rate of fertilization is the one that results in the largest yield. The largest yield should naturally be understood to mean that of a quality suitable for the purpose of production.

My answer is thus that the optimum amount of fertilizer must always be applied, but what should be understood by this optimum must be determined by an analysis of the particular case. Under the conditions outlined in the question the optimum amount of fertilizer is the one that give the largest yield of a quality suitable for the purpose of production.

This statement holds true even if this optimum amount of fertilizer is not profitable under the given regulator and price system. This may seem to be a contradiction, yet the contradiction in this case is in the regulatory system. It sometimes happens in Hungary, as elsewhere, that the regulatory system and the prices take some time to reflect the interests of the national economy, so the amount of fertilizer which is optimum at the level of the national economy may temporarily cause a deficit to the producer, or on the contrary, a rate of fertilization that causes a loss to the national economy may be profitable for the producer.

In Hungary sugar-beet production is a good example of this. The amount of fertilizer is not a limiting factor at present. The aim of sugar-beet production is to meet the domestic sugar requirements, as in general Hungary relies on sugar imports. The size of the agricultural area suitable for sugar-beet production is also a limiting factor. At the same time, owing to the limited size of the total agriculturally cultivable area it is obviously in the interests of the national economy to produce the domestic sugar requirement on the smallest possible area.

Under such conditions the optimum amount of fertilizer on a national scale is that which gives the largest yield of extractable sugar per ha.

As long as the delivery price of sugar-beet was determined by weight, owing to the imperfection of the regulatory system, the individual producers were only interested in attaining as large a yield as possible, so they found the use of large amounts of fertilizer profitable even if these increased the yield at the expense of the amount of extractable sugar per ha.

Efforts have been made to set up a regulatory system which gives a better reflection of the interests of the national economy, so first a premium was granted for sugar content, and in the near future a change-over to acceptance by sugar content will take place. This will still not be a perfect solution. Even if the sugar content is the same the amount of extractable sugar may vary greatly according to the quantity of substances other than sugar contained in the sugar-beet. In other words, only a system of acceptance based on the amount of extractable sugar per ha would really reflect the interests of the national economy. This will be so as long as no other limiting factor has to be taken into consideration.

DEBRECZENI, B.: In planning the nutrient supply and determining fertilizer requirements, increasing use is being made of scientific methods and equipment; and farmers are also trying more and more often to find an answer to the question, what kind of nutrient would be most profitable and in what quantity. In the present Hungarian system of economic management the farms are generally equally interested in increasing their production and their income, in which a decisive role is played by fertilizers. The extent to which fertilization costs rise parallel with the increase in yields and profits is thus a matter of importance.

An analysis of the yield-income relations of fertilizer costs, especially in the case of medium or high rates of fertilization, reveals important correlations from the point of view of the permanent and changing costs of production. The *permanent costs* of crop production (soil cultivation, plant tending, seed, buildings, machines and equipment) are practically the same whether the yield is high or low. In contrast to the permanent costs of production, the rise in production is a function of the increase in the *changing costs*, of which the fertilization costs are the most important (about three-quarters).

It is essential that the profitability indices for fertilization should be based on the actual natural and economic situation. This criterion can be fulfilled by comparing an area not supplied with nutrients (of kept at the lower nutrient level of a previous period) with a fertilized area when considering the yield and the production value per unit area.

It can be established that the optimum fertilizer profitability occurs at the maximum level of net income per unit area. A rate of fertilization which provides maximum net income per unit area is thus regarded as optimum. The use of fertilizers is thus profitable as long as the value of the surplus yield exceeds the total costs of fertilization plus the harvesting costs of the surplus yield.

In my opinion, an increase in the rate of fertilization beyond the level of profitability can only be allowed under the pressure of certain economic circumstances (deficient fodder supply, shortage of food).

GYŐRI, D.: It is reasonable to increase the rate of fertilization somewhat beyond the optimum. This increase may be 10—20%. The reason why somewhat more than the optimum is required is that the nutrient supplying capacity of the soil can only be raised to a higher level with quantities larger than those extracted from the soil. In this way plant varieties with higher production potentials can be better supplied with nutrients and will thus be able to produce larger yields.

HARASZTI, E.: The first aim at present is to increase the rate of fertilization to the optimum, i.e. to the limits of profitability, since at present we are still far from this level on a large scale. In the long run, however, it might be necessary to continue to increase the rate of fertilization as long as surplus yields are attained. In this respect, however, the optimum, and later the maximum production of nutrients is regarded as the standard of value rather than the absolute quantity, especially for fodder crops.

HARMATI, I.: In general. it is only rational to increase the rate of fertilization up to the limit of profitability with a view to increasing the efficiency of crop production. The following factors must be taken into account:

1) The overapplication of fertilizer may cause disturbances in plant nutrition, thereby increasing the spread of plant diseases and the damage thus caused.

2) The environment, waterways and groundwater may be polluted (particularly by nitrogen fertilizers).

3) Owing to the excessive use of nitrogen, the crop may contain NO_3 in quantities harmful to man and animal alike.

4) Considering the increasing energy problems, fertilizers must not be squandered; this applies particularly to nitrogen, since its production demands the greatest energy input.

5) Crude phosphate and potassium salts are imported.

Nevertheless, the application of above-optimum amounts of fertilizer may in some cases be expedient even now, with a view to attaining maximum yields.

If a shortage of food occurred man would be forced to increase the rate of fertilization as long as the yield could be increased without any considerable deterioration in quality. Questions of economic efficiency would then be influenced by necessity. Profitability is, in any case, a function of the price relations.

HELMECZI, B.: The principal task of agricultural production has always been, and is likely to be for a long time to come, to supply the human race with food. This might lead to the conclusion that the rate of fertilization is determined by the demand for food rather than by profitability. I do not think it would be right to start from this viewpoint alone. The right view would be to regard profitability as only one of the factors determining the rate of fertilization, and to lay greater emphasis on other factors, e.g. the ecological effects. Experience shows that in a number of cases fertilization rates which are favourable from the point of view of profitability have adverse ecological effects. This is influenced not only by the plant variety and the nutrient content of the soil but also by the type of soil and several other factors. These latter, however, could only be established by measuring quantified ecological effects in exact experiments. The measurement of the efficiency of fertilization and its influence on the environment is a highly complicated procedure that has not been widely introduced as yet. No-one has succeeded so far in quantifying the effects of fertilizers or in expressing the value of the changes that occur in the soil and in natural waters as a consequence of fertilizer application. An attempt must be made to determine the rate of fertilization on the basis of more exact and more complex analyses, so as to arrive in the shortest possible time at the point where quantities and proportions of fertilizers appropriate to the type of soil, variety of plant, weather conditions, etc. are determined on the basis of experimental results, exact measurements of quantified ecological effects, and economic calculations. The rate of fertilization thus determined should on no account be exceeded.

HUSTI, M.: The rate of fertilization should only be increased, in my opinion, as long as it profitably increases the yield. With the cultivation of new, more productive varieties the fertilizer consumption can be increased, as more fertilizer will be economically utilized by varieties which are likely to give larger yields.

KISS, A. S.: This is a difficult question, because as long as people are well fed they will only recommend the optimum rate of fertilization, but if they feel even slightly hungry they will consider a maximum yield to be necessary even if it is not profitable. The latter may have an adverse effect on the environment, not only by contaminating the soil, but also by accumulating in foodstuffs of vegetable origin (nitrate, nitrite, nitrose amine) and thus becoming a health hazard. In my opinion the rate of fertilization should only be increased to an extent where its endogenous contaminating effect still represents no danger to foodstuffs and animal feed.

Kiss, Á.: Fertilizers must not be supplied above the optimum in order to ensure the food supply of the population at any cost. Special care must be taken not to use excessive amounts of nitrogen fertilizers, primarily to prevent the contamination of the environment. The use of starter and other biologically active microelement fertilizers instead of the excessive application of macroelements is likely to be a great help.

Koltay, Á.: Of all the factors which influence the efficiency of crop production, provided the technology is suitable in every other respect, plant nutrition is the most important. The close correlation between fertilizer application and yield averages can be demonstrated on agricultural areas anywhere in the world. With increasing rates of fertilization the yield can generally be linearly increased to a certain extent. Beyond a limit value, which is highly dependent on other production factors, the fertilizers no longer increase the yield. The use of fertilizers is an important cost factor, so it is extremely important to know the economic optimum of fertilizer application. The optimum, however, is a function of so many factors (crop year, type and nutrient-supplying capacity of the soil, specific demands of the varieties, quality requirements, etc.) that it cannot be determined exactly with the means available at present. Under Hungarian conditions it is definitely justified to plough in sufficient nutrients to amply cover the nutrient requirements of the crop. In fact, the regular use of nutrients leads to saturation and to a positive nutrient balance, thus making it possible to stabilize or further increase the yield level.

In my opinion, the over-application of phosphorus and potassium can generally be regarded as a useful investment even in cases where their effects cannot be demonstrated in the year of application. Nitrogen, on the other hand, should be supplied according to the needs of the plant, up to the physiological optimum.

Kováts, A.: It is common knowledge that the additional efficiency of increasing rates of fertilization, that is, the yield surplus per kg active agent, shows a decreasing tendency. At a given level of fertilizer and crop prices this means that a level can be determined at which fertilization is still profitable. Fertilization above this level is no longer economical. In settling this question, however, an important role is played by the fertilizer conversion capacity of the variety, and by the fertilizer and crop prices. The older varieties were unable to utilize higher rates of fertilizer, so a lower level of fertilization and smaller yields were regarded as "optimum". The modern intensive varieties can utilize, or may even demand, larger doses of fertilizers. Thus, an answer to this question can only be given if the day by day results of plant breeding are taken into consideration. This means that the varieties of the future will have to be able to utilize higher nutrient levels than those which are optimum for the present varieties.

It should be noted, however, that there is an economic correlation between the prices of fertilizers and produce, so if the aim is to attain larger yields by increasing the rate of fertilization even if this is not economical, then the price of the produce must be raised.

Nor should it be forgotten, that the international division of labour makes it possible for economically grown crops to be exchanged between countries, so the use of fertilizers is always likely to increase to the current optimum.

Láng, G.: Factors which determine the level of production are generally worth applying up to the profitability optimum. This goes for fertilization too. The profitability optimum, however, does not mean an unchanged ratio between the quantity of products and the production means. This ratio constantly changes with the development of economic life, the increase in labour productivity, the amount of investments required to exploit the raw materials, and the level of technology. If we do not keep to the principle of profitability problems are caused in other fields of national economy, which then react back on the starting point. In this way only sham results can be attained, and they too will be only temporary; in the long run every branch of production must be well balanced.

LŐRINCZ, J.: The supplementation of the nutrients which are still only present in minimum quantities, but which may help to increase the yields per hectare, depends on many factors. Some of the factors which enhance linear growth are not known yet. Up-to-date research opens up new vistas in this field as well. It should be possible, for example, to produce 1 q biomass on an area of 1 m^2. And within the biomass the proportion which is primarily necessary for man as food or fodder can also be changed. (Length of stalk, number of grains, protein, fat, oil contents, etc. can be changed by breeding.)

MIHÁLYFALVY, I.: In Hungary 1 ton of mixed (nitrogen, phosphorus and potassium) artificial fertilizer active agent costs 6000 Ft at present. Consequently, at farm level increasing importance is attached to profitability. Because of the increasing doses of fertilizer efficiency will play an ever greater role. In my opinion artificial fertilization can be regarded as economical as long as 1 kg active agent produces 8—10 kg surplus yield. In the long run the increase in doses of artificial fertilizer arrives at a point where efficiency begins to lessen significantly. Provided a good nutrient balance is established in the soil of the farms, including the rational utilization of the liquid manure produced on big livestock farms and of urban sewage, it will be possible to decrease the present volume of artificial fertilizer consumption.

MOLNÁR, F.: In my opinion the utilization of fertilizers must be increased in the future in all fields of agriculture. With a view to the reliability of yield it is worth supplying fertilizers beyond the optimum, because potassium salt and superphosphate do not get washed out of the soil, and their conversion in the subsequent years depends on the amount of nitrogen applied and on the prevailing ecological factors. The nitrogen supply should be differentiated according to the crop. It is known that after-effects must also be reckoned with in the case of nitrogen fertilization. The yields now considered optimum and the fertilizer doses required to achieve them are likely to increase in the future. This expectation is supported by the fact that as the quality of the machines and implements improves more efficient soil cultivation, plant tending and harvesting can also be carried out from year to year. Due to improved farm organization and increasing specialization treatments on the plants can be carried out at optimum times. As the result of plant breeding more productive varieties are being used. The development of the industrial background has involved the extension of the irrigated area and the completion of melioration work. Various biocatalysers and other preparations are likely to be introduced in the near future, and these will result in better fertilizer conversion and a parallel increase in yields.

All in all, I think that in order to attain reliable yields fertilizers should best be supplied in quantities exceeding the optimum by 20—30%.

MOLNÁR, J.: A higher rate of fertilization is most likely to increase the yield on areas where the utilization per unit area is now at a low level. It should be noted that Prof. Fritz Baade considered the use of 120 kg/ha active agent (40 kg nitrogen, 40 kg phosphorus, 40 kg potassium) as the optimum as long ago as 1960, but only one-third of that amount is now used, and that too very unevenly (158 kg/ha in Europe, 7 kg/ha in Africa).

It is obvious that the highest yield per unit fertilizer application could be attained in Africa, Asia and South America, especially if other conditions of production also improved in these continents.

A more dynamic increase in food production is needed primarily in the countries of the third world, but the conditions required for this are not available. Therefore in the developed countries economic conditions should be created by means of which the economic optimum will come closer to the biological optimum, since the human race cannot do without this mass of food even if it is produced at increasing cost.

NYÉKI, J.: This question never loses its timeliness. The efficiency of fertilizer utilization as reflected by profitability can always be assessed only for the given historical period. Changes in food prices may mean that even if a 10 ton yield surplus is obtained with 1 ton of active agent the producers will be forced to increase the rate of fertilization. Correlations of this type can be observed today in many cases in the field of energy management.

Mention should also be made, however, of phenomena which have only been experienced as yet on an experimental scale, e.g. the effect of increased fertilizer utilization on the chemical properties of the soil, or the danger of NO_3 incorporated in the plant as a result of increased fertilizer utilization.

Thus, over and above the economic indices, the results of regular, thorough soil and plant analyses can, in fact, be used to decide the maximum extent of fertilizer application.

In our present situation much could be done towards achieving more favourable nutrient conversion indices by adjusting the rate of fertilization to the given region and crop.

PAIS, I.: Rational calculations suggest that it is only advisable to increase the rate of fertilization until the optimum surplus yield is attained, because an over-application of fertilizers may involve other dangers. In theory the primary task is to satisfy the food requirements of the human race; that is, profitability should not be taken into consideration when making decisions in this matter. Environmental pollution, as a potential enemy to the human race, may, however, be an important factor, which cannot thus be ignored.

PECZNIK, J.: The growth and development of the plant and the yield volume are influenced by many factors. The correlation between nutrient supply and yield can be characterized by a function curve whose initial phase is nearly linear, after which it flattens off, and finally, after reaching a maximum, begins to turn down again. It must not be forgotten, however, that the conversion of nutrients depends not only on their quantity, but also on other production factors (water supply, nutrient reaction of the variety, agrotechnics, etc.). Looking at the question in this way, fertilization is likely to have the highest relative effect in the backward (developing) countries, as has been demonstrated in experiments carried out by FAO. There can be no doubt, however, that in countries consuming large volumes of fertilizer the biological optimum does not always coincide with the economic optimum, though the latter is not easy to judge, as in many countries (even in some of the capitalist countries) fertilizers are granted price support. It is thus possible that the use of large amounts of fertilizer, which are no longer economical as far as the national economy is concerned, is still profitable for the farmers. In my opinion, although the food supply of the population is undoubtedly of primary importance, nevertheless, except in emergencies, economic interests must also be taken into consideration in solving the problem.

PETRASOVITS, I.: The profitability of food production can only be a decisive point of view in those countries where food production is able to satisfy a minimum level of demand. However, in many countries this is not the case.

Therefore in considering the profitability of the rate of fertilization a distinction should be made between the individual countries of the world.

In countries where food production is the basis of social progress, and often even of social existence in the future, profitability is not always a decisive factor. In this case the economic deficit should be repaid from national or international financial resources. In these countries attention should first be paid to the ecological rather than to the economic optimum. This means that the upper limit of fertilizer application is determined by the extent to which the plant is able to utilize the fertilizers, and also by the capacity of the soil and the quality of the produce (tastiness, value of components, toxicity).

PETRÓCZI, I.: I think an abundant application of nitrogen to the soil, while dangerous to certain crops, may be harmless or even desirable in other cases. It is a well-known fact that in cereals one-sided nitrogen fertilization causes etiolation of the lower node followed by lodging. The danger of rust infection increases, and difficulties are encountered when harvesting with up-to-date machines. In other cases nitrogen fertilization increases the juvenility of the host tissue, whereby the plant becomes resistant and the possibility of infection decreases (e.g. *Alternaria* leaf spot in tomato, leaf cereospora in beet leaves, etc.). In this respect crops, varieties and plots (blocks) should be considered one by one in the future, making use of adequate biochemical knowledge. This should prove possible as 1574 plant protection engineers and 873 works engineers graduated between 1970 and 1975 and refresher courses are organized for them every three years.

PLETSER, J.: The efficiency of fertilization depends on many factors, and as these factors change the optimum changes too. The rate of fertilization should always be increased to the current optimum because a decrease in the profitability may cause a fall in the living standard. When the variety, agrotechnics and soil are identical the optimum amount of fertilizer depends on the weather. Owing to the very changeable weather conditions in Hungary the optimum amount of fertilizer must be determined for the most frequent weather factors, which vary from region to region. Even so, in 20—25% of the cases the weather conditions may be such that the amount of fertilizer considered to be optimum will cause a yield depression. If the rate of fertilization exceeds the optimum, the risk involved with unexpected weather conditions increases and apart from the decrease in profitability, the yield itself will also be reduced in most cases.

Pozsár, B.: In the developed countries fertilizers are already used in such quantities that the costs correspond to the value of the surplus yield. The production and utilisation of nitrogen bound by the chemical industry is unlimited, whereas food production is limited. The occurrence of phosphorus rather than that of potassium is the limiting factor in complex fertilization. Better fertilizer application should be introduced in the developing countries too, at least in quantities sufficient to ensure a yield surplus. Within a decade or two food production programmes everywhere, in developed and developing countries alike, should include the use of artificial fertilisers in such doses that the price of the fertiliser is translated, without any decrease in value, into plant products.

Rakonczay, Z.: I think that with a view to covering the food requirements of the population the amount of fertilizers should be increased to the optimum. There may naturally be a limit beyond which this method cannot be followed. It should be noted here, that apart from social and humanitarian aspects, the realistic relationship between price and value must also be taken into consideration when determining the optimum or limiting rate of fertilization, because over and above the technical calculations, the optimum, or the suggested limit value above the optimum, may also be a function of the food and fertilizer prices.

Romány, P.: To begin at the end of the question: it is a well-known fact that at the present level of fertilization and production the basic food supply of the population of Hungary is assured; the extension of production in Hungary has been aimed for a long time at increasing exports. If the question were to be understood to include the increase in exports it would lead us too far from the subject and would fall within the scope of the discussion.

The efficiency of fertilization can best be characterized by the so-called supplementary input that is, the amount of surplus yield (in cereal units) per ton of surplus mixed fertilizer active agent, rather than by the index of surplus yield (in CU) per ton of mixed active agent. This is because in the former case the distorting effect of natural productivity (basic yield without fertilizer utilization) can be eliminated.

The efficiency of fertilization can also be characterized by a production curve which shows the relationship between fertilizer utilization and yield. The supplementary efficiency indices calculated from the national average values suggest that *we have not yet reached the optimum.*

Taking the yields obtained in the 1920s as the basis, the supplementary efficiency has shown the following trend:

Period	Surplus yield in 10 cereal units obtained with 1 ton surplus active agent (10 CU = e.g. 1 ton of wheat)
1921—1950	53 (e.g. 53 tons of wheat)
1951—1960	23
1961—1975	5.4
1970—1977	5.3

According to the law of diminishing returns the supplementary efficiency, calculated from actual national data, has fallen to approximately one-tenth. This does not mean, however, that fertilization is no longer efficient. Considering the production results and the virtually non-existent fertilizer utilization in the 1940s, the supplementary efficiency shows the following trend.

Period	CU value of surplus obtained with surplus fertilizer to the value of 1 Ft
1956—1960	13.3
1961—1965	2.8
1966—1970	4.6
1971—1975	3.0
1970—1977	4.8

To sum up: on the basis of the above indices of supplementary efficiency, and considering the total fertilizer utilization in Hungary, the problem of whether to increase the rate of fertilization, even if this means a decrease in profitability, in order to assure the food supply of the population, has not yet arisen, partly because the optimum has not been reached yet, and partly because even at the present level, which is nowhere near the optimum, the yields produced by Hungarian agriculture exceed the food requirements of the country.

SHMILLIÁR, M.: The amount and upper limit of fertilizers must be adjusted to the crop yield. Rapid development must be reckoned with; the yield of wheat, which is 50 q/ha today, will probably be 100 q/ha tomorrow, and sugar-beet is also expected to double its yield averages, etc. Under the present conditions of field crop production the mistake is often made of studying the effects of fertilizers one-sidedly, only from the point of view of nutrient replacement. This question should be examined in a much more complex way, and the fact that the soil as a whole is similar to a living organism ought to be taken into consideration. The chemical processes taking place in the soil as a result of a high rate of fertilization should be followed with attention. Efforts should be made to restore the balance. In my opinion, profitability should be judged in a different way, and yield increase at whatever cost will assume a different meaning when the increased world population is clamouring for bread.

SZALAI, GY.: Food production, like any other production, is also an economic activity. That is, the financial order of magnitude of the output is opposed to a certain financial input. Since the size of the output is also a precondition of production, the farm (whether it is small-scale or a large-scale farm) is only able to increase investments as long as the production covers the expenses and the development funds. So the rate of fertilization, too, can only be increased up to the level of profitability.

This is particularly so in Hungary as the country is a food exporter; exporting at a deficit would mean losing part of the national income. A country poor in raw materials cannot afford to do this. It is another question whether the domestic prices are sufficiently co-ordinated with the international prices. They should be levelled up in order to make correct operative decisions possible. This would be in the interests of the national economy as well.

The food supply of the world population can only be improved through international co-operation, which postulates the state subsidization of food production. In this case a rate of fertilization higher than the present one will still be economical and it will be feasible to endeavour to attain as large a yield as possible leaving the law of value out of consideration.

SZALAY, S.: The "optimum" level, or the level of "profitability" greatly depends on price fluctuations; for example, a substantial rise in the price of energy carriers involves an increase in the price of fertilizers (particularly nitrogen). It is indispensable today even in food production to have a basically energetic point of view. An overapplication of fertilizers may lead to a situation where the amount of calories introduced into the soil is almost equal to that obtained with the crop, since nitrogen, for example, is produced at the expense of natural gas, oil or coal, i.e. calories, and the mechanization of agriculture has also increased the energy consumption. Even with the present intensive growing methods, some crops (e.g. tomato, vegetables, fruits) supply less calories than is spent on their production, not to mention the early goods produced in heated plastic tents.

It seems to be much more reasonable to adjust the volume of fertilizer to be applied to the amount of nutrients (N + K + P, etc.) extracted from the soil the previous year by the crop and its by-products (e.g. straw, stalk, etc.). If the fertility of the soil is to be maintained at least as much nutrient must be replaced every year, or possibly more depending of the type of soil, because from light soils such as sand a considerable proportion of the readily soluble fertilizer enters the ground-water and is lost. Excessive fertilization must, however, be avoided, because it is energetically uneconomical, and from the point of view of environmental pollution and the eutrophization of waters it may even be harmful.

SZENICZEY, Cs.: Most economically developed countries also have developed agricultures and considerable food surpluses. Therefore the rate of fertilization is determined in these countries by the question of profitability. If a crisis arises this rule lapses.

SZÉKESSY-HERMANN, V.—FAZEKAS, S.: Profitability is only one of the determinants of the optimum rate of fertilization, and can certainly not be a criterion in the long run. An above-optimum application of fertilizers is dangerous, however, from the point of view of the future food supply of the world population.

TARJÁN, R.: An increase in the use of fertilizers is only expedient and permissible to a level and under conditions where the crop in question can utilise them and where the necessary replacement of nutrients is ensured. Increases in the rate of fertilization beyond the optimum level (which depends on the soil type, plant variety and other production and ecological conditions) are inadmissible from the point of view of environmental protection and, indirectly, food health, quite apart from the fact that this would involve superfluous additional costs. (A typical example is the harmful increase in the nitrate content.)

TOMPA, GY.: According to our present knowledge, with increasing rates of fertilization the yield can only be increased to a certain point, beyond which the amount of nutrient supplied will no longer have a yield-increasing effect.

It is therefore easy to understand that the main objective of farms is to find the economic optimum above which no additional fertilizer should be used, or at least not enough to cause significant surplus costs.

It is worth mentioning, however, that these "optima" are not stable and may change from one year to the other, since the crop and the yield may be influenced by a great many factors during the vegetation period. These factors may even affect one another, and thus the amount of available nutrients as well. It has happened, and may happen in the future too, that an amount of fertilizer above the established optimum has proved economical because, for example, the unusually rainy weather was able to turn nutrient quantities above the known optimum into a yield surplus.

Therefore, by supplying a reasonable amount of nutrient above the optimum the farm has more chance of increasing the yield, but if, for various reasons, this should not be possible, it will help to raise the nutrient level of the soil and will exercise a favourable effect on the after-crop.

Nutrient uptake from the soil is determined, among other things, by various soil properties. In calculating the necessary amount of nutrient this factor is the most difficult to determine, since the soil is primarily a transporting medium for the nutrients, and is not homogeneous from a microbiological, biological, physical or chemical point of view, but is complex and contradictory.

This is why up-to-date, regular soil and plant analysis is so important, as it gives information on the positive and negative changes occurring in the nutrient level of the soil, and outlines the necessary tasks related with the nutrient supply.

TULCZ, I.: My opinion on an increased rate of fertilization is that for the time being the optum cannot be determined, since the rate of fertilization used in Hungary is much lower than that in some countries with developed agricultures.

Profitability in this context is to some extent a function of price formation.

The food supply of the world population must, in my opinion, be solved at any cost.

*

PÁL, GY.: **When Liebig realized, in the middle of the 19th century, that nitrogen, phosphorus and potassium were indispensable for the development of plants, he laid the theoretical foundations for artificial fertilization, and simultaneously launched the fertilizer industry. In your opinion, to what extent can the efficiency of fertilization be further increased in Hungary by means of pest control, soil cultivation, better organization or agricultural work, properly chosen plant varieties, irrigation and mechanization?**

ÁCS, A.: Fertilizers must not be "deified". They cannot work wonders, but act in conjunctim with all the other yield-developing factors. Furthermore, all these factors can only act efficiently and produce results if the technical production conditions are fulfilled the human factor (not as a consumer) must also be given primary consideration. Man, the worker and manager, controls the living and non-living materials. Complete professional knowledge, time and motion studies, the management, execution, supervision and control of the production processes and the use of cybernetics will be indispensable in this work.

BARACS, J.: The possibilities of increasing the efficiency of fertilization already exist to a limited extent. The control of plant and animal pests should begin at a danger level where the costs will be returned. Extremely dangerous pests are exceptions; control is justified if they are found at all.

The correct soil cultivation, e.g. deep ploughing in the autumn carried out well and in due time, subsoiling and liming (practices not frequently applied as yet), carefully chosen pre-crops, etc., offers further possibilities for increasing the efficiency. Experimental results prove that the average yield of winter wheat, for example, was 40.7 q/ha after wheat as pre-crop, 47 q/ha after crops sown in spring and harvested early, 44.5 q/ha after those sown in spring and harvested late, and 45.7 q/ha after perennial papilionaceous crops under the same conditions. To sum up, if agricultural work is better organized yield average much higher than the present ones can be attained.

Choosing the right variety is one of the important factors of yield increase. In Baranya county, for example, the average yield of fodder wheat, which made up 50% of the total wheat area, was 6.4 q/ha higher last year than that of all the other wheat varieties together (48.8 q/ha). Among the other varieties, however, the results obtained with the new Hungarian wheats (from Martonvásár and Szeged) in 1977 were highly promising. For example, Mv 4 yielded 55.1 q on 1003 ha, Mv 5 yielded 49.2 q on 1281 ha and GKF 2 yielded 46.5 q on 1000 ha; the county average was 54.2 q for very early maize varieties, 54.7 q for early, 59.3 q for medium early and 63.9 q for medium late varieties, while late maize varieties again showed a county average of 54.2 q, that is, sowing late maize varieties under Hungarian conditions involves a risk. The potential productivity of the varieties is characterized by the following: On the 1 ha plots of the "Béke őre" Co-operative Farm at Lippó the variety SC 3369 yielded 103.5 q/ha, BA 418 104.6, TC 3420 108.8, TC 3344 114.4, SC 3444 110.6, MSC 4515 119.2 and SC 3565/A 120.3 q/ha. The average of the 16 varieties included in the experiment was as high as 100 q/ha.

As a matter of course, with irrigation, mechanization, and the full exploitation of the potential productivity of the varieties the present yield averages could be doubled.

BAUER, F.: The question can be answered in different ways depending on how we interpret the word "today". If the requirements listed were optimally fulfilled, the efficiency of fertilization could be redoubled even "today". The question is, to what extent this increase in efficiency could be attributed to fertilizer application.

If this "today" means the extent to which the optimum supply of pesticides and machines, the possibility of irrigation, etc. can actually be ensured in crop growing at present, then the possibility of an immediate increase in efficiency is not more than 10–20%.

An increase in the efficiency of fertilization and the assessment of this increase are complicated by many factors. For example, the efficiency of small amounts of fertilizers can be more successfully increased by better cultural practices than that of nearly optimum or maximum rates. The situation is made more complicated by the fact that "today in Hungary" it is in inproductive farms which use little fertilizer and thus have the greatest theoretical possibility of increasing the efficiency of fertilization that there is the least hope of raising the agrotechnical level, and so on.

BEKE, D.: Some 40–50% of the yield increase over the past fifteen years has been due to the higher rate of nutrient supply. The improvement of soil cultivation produced a 20–30%

increase. The remainder (20—40%) can be attributed to other factors. Efficiency can be increased in the years to come by better soil cultivation, by improving the water capacity of the soils, by reducing losses through better organization and work discipline, and by the extension and intensification of plant protection.

Beke, I.: The efficiency of fertilization can be considerably increased today, primarily by better organization, irrigation, improvement of the nutrient-supplying capacity of soil, and by providing an adequate technical background.

There are incalculable perspectives in the improvement of plant protection, proper soil cultivation, the production of new varieties, and in the factors listed above.

Particularly in the field of plant protection we can witness the development of new economic ideas, according to which plant protection is an up-to-date production tool. In crop production a structural change is taking place in the production tools; at a higher technological level a number of mechanical, etc. procedures are being replaced by more up-to-date, productive chemical methods.

Buzás, I.: An increasing number of researchers state and prove that by generalizing Liebig's law and extending it to cover all production factors as well as the active agents, it is impossible to set an upper limit to its validity; consequently, Mitscherlich's law does not hold true, or at least is not a law.

When generalizing Liebig's law it is regarded as holding true in respect of mineral nutrients, plant protection, soil cultivation, variety, plant number, agricultural operations, work management, soil type, temperature, sunshine, oxygen and carbon dioxide, etc., that is, in respect of all known or as yet unknown production factors.

As the minimum production factor increases the yield shows a linear increase which lasts until another factor or factors become minimum. From then on the increase in yield, according to Liebig, is zero, while according to Mitscherlich it is not linear, that is, it gradually decreases, or a reduction in yield may occur.

If we consider that the staves in Liebig's barrel are not of the same width, in other words, not only factors whose values are of decisive importance are present, but a multitude of quite small gaps are also found in the barrel, through which the copper only oozes, so several factors could well be reduced to a relative minimum at the same time, and the yield could still increase, though not linearly. These gaps also represent the gaps in our present knowledge, which multiply as crop yields increase and become more and more difficult to recognize. When they are eliminated, however, the yield curve will become linear again.

If we accept the fact that the world is cognizable, it must be stated that the validity of the Liebig law has no upper limit. The yields will be capable of increasing far beyond the limits that can be imagined at present, because as the level of human knowledge rises the descending section of the yield curve can always be made linear.

Among the factors listed in the question as having an influence on the crop yields (pest control, variety, irrigation, etc.), and also apart from these (e.g. heat, sunshine, carbon dioxide, etc.) innumerable production factors exist, the co-ordination of which, at least of those already known, is not an unfeasible task even now. Yield increases are restricted at present by the financial means available for this purpose rather than by the level of knowledge, since there are two things that can set a limit to the boundless increase of yields: one is the level of knowledge accumulated at a given stage of the socio-economic development, the other is the financial means that can be spent on an increase in crop yields. The development of these two should be in harmony with the rise in food demands.

We can only hope that when we reach the point where the existence of the human race depends on how the problem of food production is solved, the intellectual and financial resources required for this, purpose will in fact be spent on self-preservation.

Csilléry, M.: Increasing the efficiency of fertilization is a complex task. The application of a high rate (5—8 q/ha active ingredient) of fertilization will only be profitable if the rules of proper soil cultivation are kept, diseases and pests are regularly controlled, the most suitable plant varieties are chosen, and the optimum time and quality of various work processes is ensured by an adequate level of mechanization and good organization.

According to present ideas, 6—10 q/ha of mixed active ingredient is considered to be a high rate of fertilization. This could, however, be increased considerably provided other conditions make it possible. If all the criteria are satisfied at an optimum level, I would expect breeding to be the basis of further progress.

Plant breeders are still faced with a great number of tasks. If wheat alone is taken into consideration, there is a need for varieties resistant to various pests and pathogens, which have higher standability and productivity and a more economical utilization of water and nutrients.

The present results could not have been attained without suitable varieties. A 60—70 q/ha yield of wheat and 80—100 q/ha maize under farm conditions would have been inconceivable 25—30 years ago.

Maize yields exceeding 200 q have been recorded in field experiments.

These results suggest that providing the necessary conditions are created an incalculable increase in yield may be expected.

DEBRECZENI, B.: Studies on the correlations between fertilization and yield, and on the interactions between fertilization and the level of agrotechnics suggest that if the agrotechnics are really good larger amounts of fertilizer can be profitably used than with average cultural practices, because with the higher level of agrotechnical factors mentioned in the question the efficiency of fertilization, that is, the surplus yield per unit active ingredient, will also increase. The extent to which the individual factors improve the efficiency of fertilization cannot be expressed by an average figure, yet I think that if all the changeable production factors were simultaneously altered according to the optimum law the effect of fertilization could be increased by some 50—100%, as shown by the example of the production systems.

HARASZTI, E.: In Hungary the efficiency of fertilization can be increased by nearly 100%, depending on the plant species and varieties, as shown by the results achieved on farms with outstanding productivity. The cultivation of varieties and hybrids which give large yields, are responsive to high rates of fertilization and irrigation and are best adapted to the ecological conditions of the given region is of particular importance.

HARMATI, I.: In 1976, 254 kg/ha NPK active ingredients were used in Hungary, which is enough to produce a yield considerably larger than the present one. The efficiency of fertilization on a national scale could be substantially increased, as proved by fertilization trials carried out at various research sites as well as by the results of the most efficient farms. In order to increase the efficiency of fertilization, however, the factors influencing it must be well known. They are:

1) The rate of fertilization. Many farms use much too much, and others much too little fertilizer.

2) The ratio of fertilizers. In many places the nutrient demand of the plant, the soluble NPK content of the soil and the pre-crop are still not given proper consideration.

3) The nutrient demands of the plant species and varieties.

4) The soluble NPK content of the soil. If this is unknown fertilization cannot be properly carried out.

5) The type of soil, which influences the utilization of nutrients (calcium content, hydrolytic acidity, mechanical structure, water regime, humus level, etc.). In acid soils, for example, liming fundamentally improves the conversion of fertilizers and the nutrient-supplying capacity of the soil.

6) Pre-crop.

7) Quality of soil cultivation.

8) Level of plant protection.

9) Number of plants/ha.

10) Standard of water supply. Under favourable precipitation or irrigation conditions the nutrient supplies of the soil are better utilized than under dry conditions.

11) Fertilizer quality.

12) Technical standard of distribution.

13) Manner and timing of fertilizer application.

14) Adjustment of nitrogen fertilization to the type of soil (e.g. Agronit or Péti salt for acid soils).

The experiments show that if attention is paid to each of these factors the efficiency of fertilization is increased to a greater or lesser extent. If they were applied in harmony the efficiency of fertilization could be greatly increased. Reckoning with an average improvement of only 4—5% per factor, which is a very modest estimate, the efficiency of fertilization could be increased by some 50—60%.

This is only a rough estimate, but if the 20—50% increase in efficiency achieved by liming acid soils, the 10—30% improvement attained by irrigation, or the 20—100%

higher efficiency achieved by using the right amounts and proportions of fertilizers are considered this 50—60% estimate does not seem so unrealistic.

I believe that a radical change could be brought about by providing adequate expert advice based on soil analyses, by using good quality fertilizers of the required composition, and by storing and applying them properly.

Helmeczi, B.: There are great possibilities latent in the application of the procedures mentioned in the question. I think the efficiency of fertilizers could be increased through the complex development and application of these procedures. It would be rather difficult to give figures or percentages to express the increase in efficiency. The difficulty lies mainly in the fact that in this connection no reliable experimental data are available as yet. For my part I should definitely add the further possibilities inherent in the application of organic substances and in soil amelioration to the procedures mentioned. I attach particular importance to the combined use of various organic substances (liquid manure, communal sewage and silt, straw and other organic refuse) and artificial fertilizers. This would not only increase the efficiency of the fertilizers, but would also intensify the fertility of the soil, improve the quality of the yield and reduce environmental pollution. Experiments show that the combination of these organic substances with artificial fertilizers stimulates the biological activity of the soil and, what is at least as important as this destroys the pathogenic microorganisms which may be introduced into the soil with liquid manure, communal sowage and silt. It is a well-known fact that on areas (mostly natural ecosystems) where the vegetation is not removed from the soil over a long period of time, decayed plant parts return to the soil, thereby ensuring a permanent balance between the soil and the plant. The situation is quite different on agriculturally cultivated areas (cultural or agrarian ecosystems), from where the plants are mostly removed to be used elsewhere. As the yields increase in size the soil becomes more and more depleted of nutrients, the replacement of which, as far as the biogenic elements (particularly nitrogen, phosphorus, potassium and calcium) are concerned, is carried out regularly by means of artificial fertilization. This, however, is only one aspect of the maintenance of soil fertility, while the other aspect, i.e. the biological activity of the soil and the activity of microorganisms, is pushed more and more into the background.

Husti, M.: The efficiency of fertilizers can be increased by supplying them at a rate which satisfies the nutrient requirements of the cultivated plants during the vegetation period. The ratio of active ingredients contained in the fertilizer should meet the special requirements of the crop. A deficiency of any of the active ingredients decreases the effectiveness of the others.

Plants attacked by various pests are not capable of normal nutrient uptake, so they only partially utilize the nutrients supplied, which reduces the efficiency of fertilization.

Soil cultivation is of decisive importance in shaping the life of the soil. It is by soil cultivation that the conditions necessary for the cultivated plants are brought about. Nutrient uptake requires sufficient water to be contained in the soil; since, in my opinion, this is a determinant of the yield, soils must be kept in such a state that they are able to take up and retain precipitation or irrigation water.

The different nutrients are introduced into the land in the course of soil cultivation, so they should be placed at a depth where they will be available to the plants.

Large amounts of fertilizer are only utilized by varieties capable of producing large yields, so constant attention must be given to the occasional inclusion of new varieties in production. In my opinion this possibility is not exploited in Hungary; even in the crops which are grown on the largest areas 20—30% of the varieties are out-of-date, and for some crops, e.g. sunflower, this percentage is still higher.

Land is of enormous value and must be exploited to the maximum.

Rational, careful soil cultivation, varieties capable of producing large yields and a balanced nutrient supply could increase the yields by 15—20% on many farms.

Kiss, Á.: For the time being we do not know where the limit is. The aim is to develop known cultural practices, breeding, disease and pest control and methods of fertilization to such an extent as to ensure the food supply of the increasing world population.

The large world organizations should follow the development of world production with constant attention. If they see that the balance between world production and the increase in the world population is threatened, they must draw the attention of the governments concerned to the importance and necessity of family planning.

In Hungary there is no over-population problem, so with increased fertilizer efficiency, more skilful disease and pest control, improved cultural practices and more intensive plant varieties the development of agricultural production can be ensured for several decades.

KOLTAY, Á.: The conversion of fertilizers is determined by their reactions and by the changes occurring in their reactions in the course of plant nutrition. The efficiency of fertilization can be considerably increased by an exact knowledge of the interactions between the applied substance and the soil, and by the elimination of adverse effects.

Physiological optima, nutrient ratios best suited to the conditions, and the detection and elimination of deficiency symptoms may substantially increase the efficiency of fertilization. The effect of the large amounts of fertilizers used in Hungary is spoilt by the unevenness of mixing and distribution; improvements in this respect would also increase the efficiency.

KOVÁTS, A.: The efficiency of fertilization is a calculated value, the order of magnitude of which is influenced by many factors, e.g. the level of cultural practices, the variety grown, etc. In Hungary there are ample possibilities for increasing the efficiency of fertilization, particularly considering the fact that some of the producing farms carry out fertilization in a routine manner, so that the rate of fertilization is often either higher or lower than necessary. The efficiency of fertilization can be greatly increased by improving the production factors, especially by more fully exploiting the potential productivity of the varieties.

The index of efficiency is lowered when fertilization is carried out in order to compensate for bad cultural practices. According to our experiments, for example, a month's delay in sowing compared to the optimum sowing time results in certain years in a yield loss, which can only be made up for with about 100 kg/ha NPK active agent. While this amount of fertilizer actually increases the yield when the crop is sown at the optimum time, in our example it only makes up for the agrotechnical deficiencies. The calculated value of efficiency will thus be different in the two cases.

The high-yielding intensive varieties considerably improve the index of economic efficiency. With identical rates of fertilization the larger the harvested crop, the higher the yield per 1 kg active agent. The available data are not sufficient at present to assess the possibility of increasing the economic efficiency of fertilization inherent in agrotechnics and variety.

LÁNG, G.: Fertilization, and in general an optimum nutrient supply to the plants, is a precondition for attaining large yields and must be ensured as a basis if the yield averages are to be increased. The more closely the conditions for the optimum nutrition of plants can be approached with doses of fertilizer, the more "efficient" the fertilization can be regarded as being. It is extremely difficult to find an index that gives a true picture of the actual efficiency of fertilization. The index often used at present, which shows the kg amount of fertilizer active agent distributed by the farm for the production of 1 q main crop, does not only give information on the efficiency of fertilization, but can also be related with the choice of variety, the level of soil cultivation, or with any other agrotechnical factor. The fact that a farm uses 12 kg fertilizer active agent to produce 1 q wheat may be the consequence of a badly chosen variety, serious deficiencies in the soil cultivation, or unsatisfactory plant protection operations, but it may equally be due to delayed harvesting, or to the wrong proportions of the individual types of fertilizer, and may naturally be the result of uneven fertilizer distribution. Thus, this index in itself does not reveal the cause of the phenomenon, which must be found in each case by detailed investigations.

LŐRINCZ, J.: The response to fertilization may vary even within a variety. New varieties are needed which have different reactions to fertilization. These will naturally have different habitats too. The role of sunshine is also very important, e.g. the position of the leaf and the angle of incidence change the extent of energy transformation. These all represent tasks for the breeder. In addition the soil-nutrient-plant relation also needs improving. The role of ecology cannot be reduced to the level of soil, variety and nutrient.

The factors that shape the yield are highly diversified: successful pest control, well-planned soil cultivation, up-to-date varieties and the optimation of factors which are at a minimum may result in a radical change in the quantity of yield, and even in its quality. More attention must be paid to these factors in the future, since the emphasis which has so far been laid on quantity may shift substantially due to the demand for quality.

Mihályfalvy, I.: In Hungary one of the basic problems in intensive agricultural development is to increase the fertility of the soil.

By optimizing the biological and agrotechnical factors crop production can be considerably increased. A good example is the 100 q/ha grain yield of maize in some farms, which corresponds to 200 q/ha total dry matter production for whole above-ground plants.

In soils with favourable physical and chemical properties, well supplied with nutrients, the utilization of artificial fertilizers by plants is more moderate than in poor soils. If the necessary biological and agrotechnical factors are provided, in the better soils rational artificial fertilization may result in a 20–30% yield surplus, on average, while in poor soils this may amount to 40–50%.

Molnár, J.: Crop yields in Hungary could be increased by an average of 60% by the year 2000, i.e. to 65–70 q/ha in maize and to 55–58 q/ha in wheat, since even now the country is in the vanguard of agricultural production in Europe.

A considerably greater increase can be attained in roughage and grass production. Even a 100–150% increase in the yields of these crops may be a reasonable objective. On these areas the main causes of stagnation are out-of-date cultural practices, the absence of appropriate harvesting machines and the lack of conditions necessary for preservation.

In some crops, e.g. in sunflower, the yield could be doubled by the turn of the century. The present low yield average of this crop is caused by the lack of high yielding and resistant varieties. Hybridization could result in rapid progress.

Nyéki, J.: According to American authors the efficiency of fertilization is responsible for about 60% of the surplus yield (over and above the natural fertility of the soil); 10% can be attributed to soil cultivation, 10% to plant protection, 10% to the variety and 10% to the correct plant number.

Of course, if the above factors are co-ordinated, then the absolute value of the relative numbers will be higher. The more extensive the conditions (bad soil cultivation, neglected plant protection, etc.) under which fertilizers are applied, the lower the efficiency.

The most important precondition for increasing yields is the well-balanced development of the national economy, in the course of which the basis could be a highly developed industrial background. A high level of agronomical work with a strong biological bias must be built up on this, and should include up-to-date plant protection, breeding aimed at producing varieties with higher productivity, and cultural practices (control of organic matter turnover, chemization fertilization, etc.) performed with modern equipment.

In addition to all this, there are still great possibilities for increasing yields Taking the present national production level of our two most important crops, wheat and maize, as a basis, and considering that farm averages as high as 58–62 q/ha for wheat and 85–100 q/ha for maize also go towards making up the national average, the yield of farms with low yield averages can certainly be increased by the right professional guidance and amelioration of soils. However difficult it is to characterize the possibilities of a yield increase using numerical data, I do not think I should be too far out if I say that an average yield of 50–55 q/ha for wheat and 65–75 q/ha for maize could be attained. The production area of our two major crops may be reduced in the distant future, i.e. the area intensity may increase, and the land thus released will be utilized for more successful profitable crops and providing an opportunity for development aimed at increasing the intensity of livestock farming.

Pais, I.: In my opinion agricultural production and the efficiency of fertilization in Hungary can only be promoted through the simultaneous improvement of other parameters. The extent of this increase in production could reach three times the present, quite high level of production, and in this increase not only fertilization, but also other parameters such as the selection of suitable plant varieties may play an important role.

Pecznik, J.: The yield averages of farms in Hungary show considerable variation, due mainly to different site conditions. However, not infrequently great differences in yield average are found between farms with nearly identical natural conditions. There may also be considerable differences in yield between partner farms within the same production system, where the technology applied, including the amount of fertilizer to be used, is strictly laid down. Measurements have shown that even within the same field adjacent strips may produce different crop results, due, for example to the uneven distribution of fertilizer or pesticide. I am of the opinion that by strictly observing the rules of up-to-date agrotechnics, yield averages could be increased by some 50% on a national scale, assuming identical levels of nutrient supply.

PETRASOVITS, I.: With the best varieties known at present, by using the factors mentioned in proportions varying according to the plant species, different results can be attained in different parts of the country and even on individual farms. The question is, however, whether the resultant of this multicomponent system is really an "increase in the efficiency of fertilization", or if it is not rather a case of increasing the efficiency of systematic crop production, which, naturally, cannot be carried out without more intensive fertilization.

PETRÓCZI, I.: On sloping areas used for agricultural cultivation water running off the soil surface may carry with it the fertilizers and some of the pesticides. Since standing waters and water reservoirs may thus become contaminated, environmental protection measures must be taken. An OMFB (National Committee on Technical Development, NCTD) study is in progress on the subject "Protection of utilizable water supplies with regard to water pollution due to the chemization of agriculture", on the basis of which resolutions will be put forward. It is not, however, sloping areas alone that are concerned here, as the infiltration of fertilizers and pesticides into loose sandy soils is just as dangerous from the point of view of drinking water. Contamination may later be transferred to deeper layers of belowground waters. The human sanitation aspects of the protection of surface and subsurface water supplies in the region or on the farm in question must be known to those engaged in agricultural production. Hungary's national plant protection and agrochemical network, which comes under the direction of the Plant Protection and Agrochemical Centre of the Ministry of Agriculture and Food, is managed at an up-to-date and internationally accepted level. Accordingly, the obligations undertaken by Hungary in international agreements and co-operation are taken into consideration when formulating the necessary measures. According to our present knowledge chemization will play a decisive role in the following 10—20 years in spite of the objections rightly made all over the world on behalf of environmental protection. The fertilizer consumption will continue to grow, and the herbicides which are dominant in plant protection are unlikely to be replaced or supplemented by other integrated methods of weed killing. In my opinion, although the drift of fertilizers may be considerable when fertilizers are incorrectly applied (e.g. just before snow melts), the leaching of nutrients has not yet reached a level which is harmful to the environment, in spite of local problems which arise mainly in the case of wells. The comprehensive measures planned should result in a satisfactory situation.

POZSÁR, B.: The level of agricultural production on large modern farms is gradually approaching the record yields obtained in macroplots (144 q/ha in Mexican wheat, 128 q/ha in Triticale, 168 q/ha in maize, 67 q/ha in soybean). Plant breeders are generally of the opinion that large farms are not able to exploit the full yielding ability of the varieties. The record yields are obtained with a high rate of fertilization. By using regulators quality deterioration can be corrected in many cases on a farm scale as well. Regulator research is aimed partly at a better uptake of macro- and microelements and partly at higher production biological efficiency. In Hungary one of the simplest ways of increasing yield averages is to promote the development of farms whose productivity is still less than average.

RAKONCZAY, Z.: It would be impracticable to give numerical data on the problem, but I think that the efficiency of fertilization could be greatly increased not only by disease and pest control, careful soil management, better organization of agricultural work, irrigation, mechnization and the correct choice of plant varieties, but also by specialization within the country and on an international scale, that is by decreasing the tendency to self-sufficiency to the lowest possible level.

Romány, P.: The efficiency of a single production factor can generally be determined only by highly complicated calculations. The factors influencing the crop yields can be divided into two large groups.

One of the groups includes those factors which directly influence the yield but require nutrients to make their effects felt. These are the variety, the plant density, etc. The other group of factors, though it is also related to nutrients, acts indirectly, and there is no need for nutrients to become objectified in the plant yields (e.g. the plant is protected with a pesticide).

Some of this second group of factors are indispensable if a yield is to be produced (e.g. sowing, plant protection, harvesting, etc.), while others promote the utilization of nutrients (e.g. correct method of fertilizer distribution and ploughing in). The supplementary inputs do not affect all the factors of the total input. Plant protection, for example, is necessary irrespective of whether we want to produce 30 or 50 q/ha of wheat. Sowing, ploughing, harvesting, etc. must also be carried out irrespective of the quantity of yield.

These factors do not figure with their full weight in the supplementary inputs, but only to the extent required by those technical developments (new variety, new, more efficient pesticides, etc.) which are carried out with a view to attaining surplus yields. (Taking the technical level of the 1930s into consideration, this is about 20%.)

Accordingly, the proportion of the supplementary inputs made up of materials (fertilizers) which will be built into the crop increases. On the basis of numerical data from recent years, taking the national cropping structure into consideration, this amounts to 55—60%. (On the other hand, the cost of fertilization makes up only 30—35% of the total production costs, since the latter includes items, e.g. sowing, which are practically independent of production results.)

On the above grounds it can be said that the supplementary efficiency of fertilization can be increased, though the extent of this increase is difficult to foretell. With the introduction of a higher yielding variety the supplementary efficiency of fertilization may suddenly rise.

The efficiency of fertilization also has an agrochemical and agrotechnical aspect. This concerns the percentage of fertilizer active agent incorporated in the plant from the total amount distributed. If this agrochemical and agrotechnical efficiency, which is of course closely related to efficiency as approached from an economic point of view, is to be increased there must be a reduction in losses in fertilizer active agent (e.g. modernization of storage), in fixation in and leaching from the soil (by distributing the fertilizer applications in time and applying fertilizers at different depths), and in losses of nutrients by erosion (by means of melioration methods).

Source of losses	Average extent (%) of losses
Storage, manipulation, distribution	10—15
Agrochemical conversion (fixation, leaching, etc.)	20—60

In the long run the agrochemical and agrotechnical efficiency of fertilizers can be increased by some 20—40% by establishing a network of fertilizer storehouses, introducing new liquid fertilization technology, and carrying out regional melioration, etc. With the present varieties, cultivation techniques and economic conditions this means an increase in supplementary efficiency of about 15—25%.

Shmilliár, M.: I have already referred to the fact that under natural conditions the soil is so interwoven with life that it can practically be regarded as a living organism itself which possesses all the properties that ensure agricultural production. When interfering with this life great care should be taken to use the right substances in the right composition and under optimum conditions, lest our interference upset the balance or cause the overdominance of one factor or another. If we can ensure the nutrient replacement taking all the necessary conditions into consideration, then the efficiency of fertilization will be substantially increased compared to its present level.

SZABÓ, B.: Taking into consideration the present level of production, importance should be attached to the analysis of factors influencing the efficiency of fertilization, one of the fundamental components of production. These factors are soil cultivation, the water supply and variety.

Soil cultivation is extremely important for the conversion of fertilizers. It is obvious that in a badly cultivated soil the physical conditions are not favourable for the microorganisms, and thus the fixation and exploitation of fertilizers is limited while the possibility of leaching increases.

It is thus clear that an increase in the efficiency of fertilization, and successful crop production in general, can only be achieved through careful soil cultivation.

There are still great deficiencies in this field, but we have vast reserves; in my opinion a considerable (10–20% or more) increase in yield could be attained if this single production factor alone were improved.

The role of irrigation is particularly important in periods poor in rainfall, but a substantial increase in yield can only be attained in any case when the natural precipitation is complemented with irrigation. Since the nutrient supply is generally planned taking the productivity of the crop to be grown into consideration, the role of irrigation is becoming more and more important. It is primarily on the dry lowland areas that irrigation may result in a substantial increase in yield. With water supplement the yield of maize, one of our most important row crops, can be raised to above 100 q/ha without any significant extra input.

The situation is the same in the case of sugar-beet, sunflower or silage maize.

The role of the variety in the yield trend is very important, though the yield cannot be satisfactory unless the other production factors are at an adequate level.

The easy availability of nutrients is already necessary to our current varieties, but it will be increasingly required as hybridization develops, since the reactions of the future varieties will be considerably better. Assuming that the efficiency of fertilization depends on the fertilizer composition, soil, precipitation conditions, and last but not least on the variety, then as far as the latter is concerned, the most suitable variety will be the one that ensures an increase in efficiency. A well-composed crop structure, with the varieties chosen in the light of the local circumstances, is a full guarantee of high yield levels.

Work organization is a factor which acts indirectly since the proper sequence and optimum timing of the work processes combined with a high quality of work ensure the efficiency of fertilization, while in the opposite case they make it impossible.

It should be noted that although it is an indirect factor, it may have a decisive role, since the quality of the organization is in direct proportion to the quality of the work. There are a particularly large number of unexploited possibilities in this field.

The control of pests indirectly influences the efficiency of fertilization, as they may hinder the growth and development of plants or destroy the mature plant, thereby reducing the amount of yield. Thus, this factor is also of importance.

Mechanization can provide conditions for the plants which ensure the full exploitation of the potential productivity. Good quality tractors are required first and foremost, furnished with a sufficient number of implements. In Hungary the greatest problem at present is the lack of co-ordination between tractor and implement production, that is, high capacity tractors are already available, but adaptors are only manufactured in exceptional cases.

Since the efficiency of fertilization is in question, it should be pointed out that the lack of satisfactory fertilizer distributors represents a particularly serious problem. The distribution is not sufficiently uniform, which is not only due to the machinery but also to the fertilizer manufacturing. A quality improvement in this field could result in a considerable yield increase.

Fertilizer manufacture raises considerable problems; complex fertilizers are scarce, the available fertilizers are not sufficiently homogenized and their distribution is difficult even if good machines are used for this purpose.

To sum up, with the improvement of the factors mentioned crop production could, in my opinion, be increased under Hungarian conditions by a further 20–25% on a national scale.

SZALAY, GY.: The efficiency of fertilization can be increased with any of the factors listed (method of fertilizer application, plant protection, soil cultivation, work organization, improved varieties). Under Hungarian conditions the efficiency of fertilizers can, in my opinion, be increased at present primarily through the proper cultivation of the soil.

According to my investigations and experience this factor could result in 10—15% higher yields with the same amounts of fertilizer. I consider the better organization of agricultural work to be of almost equal importance. I am thinking here particularly of keeping to the optimum sowing and harvesting dates.

SZALAY, S.: The yields per ha in Hungary still vary greatly from one farm to the other, due mainly to differences in soil conditions, knowledge, development level, organization, work discipline, and partly in the means available (mechanization, current assets, etc.). It is obvious that as soon as all the farms and co-operatives where production is not yet sufficiently up-to-date reach the level of the best farms, the volume of production can be increased to a great extent. In Hungary, as elsewhere, a lot could still be done in the field of propagating knowledge, improving organization and work discipline and increasing the workers' interest in production.

SZENICZEY, CS.: My answer to this question may be a little Utopian. The efficiency of fertilization can, in theory, be boundlessly increased by the development and optimum application of the elements mentioned in the question. The reduction to a minimum of the enormous losses during harvesting, storage and processing represents a great reserve for the relative increase of food production.

The conditions necessary to redouble our present yield averages could be created within a reasonable time.

SZÉKESSY-HERMANN, V.—FAZEKAS, S.: Statistical data show that there are great differences in fertilizer efficiency between the counties. The complex nature of efficiency is also shown by the fact that an assessment of the potential reserves in Hungarian agriculture, obviously taking into consideration the technologies known at present, was designated as a central task at the 1978 general assembly of the Hungarian Academy of Sciences.

TOMPA, GY.: At present production possibilities in Hungary are only exploited to 35—40%. Although crop production shows a steadily rising tendency, the rise is relatively slow and there are considerable fluctuations. Each of the factors mentioned in the question is able to exert an effect that can be expressed in a yield surplus. The effect would, however, be much more intensive and significant if these factors were made use of in production not one by one, in different years, but in a complex manner over a short period of time.

TULCZ, I.: The efficiency of fertilization is very difficult to study, as many other factors play a part in shaping the yield. It is obvious that any factor that acts on the plant in the course of production has an influence on the efficiency of fertilization.

Nowadays frequent references are made to Liebig's law, because this rule is coming more and more to the fore, and minimum factors are found to limit the quantity of yield.

It is known that fertilization is the most important factor in yield increases. In my opinion, if the factors listed in the question are provided to an optimum extent, at least 50% larger yields could be obtained at the present rate of fertilization. We thus have vast reserves in this field.

I think it is unnecessary to analyse the factors mentioned one by one, as all of them — disease control, correct soil cultivation, better work organization, increased choice of variety, irrigation, mechanization — carry in themselves the possibility of further development.

*

PÁL, GY.: **With the present price of wheat at 290 Ft/q and that of nitrogen active agent at 6.58 Ft/kg, 1 kg nitrogen active agent can be bought in Hungary for the price of 2.2 kg wheat. Knowing that the nitrogen content of green plants is only 0.30%, and that the disease resistance of cultivated plants decreases when there is an abundance of nitrogen in the soil and the plants, do you consider an abundant supply of nitrogen to be dangerous, permissible or correct from the point of view of phytopathology and plant protection?**

ÁCS, A.: The question raised is whether an over-application of nitrogen would not cause considerable losses of yield by making the plants susceptible, or less resistant, to various pathogens.

Nitrogen does, indeed, have this effect on certain crops, and if the ecological factors act in the same direction, certain diseases may arise.

This is not, however, a sufficient reason for reducing the nitrogen fertilization. The solution is to increase the disease resistance of the plants genetically, through breeding. Improvement in the microecological conditions (e.g. by avoiding over-dense plant stands) also reduces dangers of this kind.

Basically I consider an abundant nitrogen supply to be correct practice, provided its harmful effects are counterbalanced by other factors.

Baracs, J.: The nitrogen supply of the soil should be considered from two points of view:
— the nitrogen supplying capacity of the soil,
— the optimum productivity of the variety.

The nitrogen supplying capacity of the soil is related to its humus content. In the case of winter wheat, analyses performed in the Central Laboratory of the State Farm, Pécs, between 1973 and 1977 showed the following correlations for various wheat varieties grown on 65,000 ha:

Humus content of soil, %	N active agent, kg/ha	Yield, q/ha
1	134	28.0
1.0—1.5	147	39.4
1.5—2.0	136	41.5
2.0—2.5	129	46.4
2.5—3.0	111	48.9
3.0—3.5	100	53.2
above 3.5	97	51.0

Apart from its influence on the yield, excessive nitrogen application, particularly in dense stands, was found to favour the development of fungal diseases (e.g. powdery mildew, foot diseases, etc.), and may promote the selection of weed species which require nitrogen.

Bauer, F.: In my opinion, phytopathological and plant protection points of view should not be obstacles to a reasonably abundant but economical nitrogen supply which fully covers the requirement of the plant and increases the yield. Wherever this problem arises plant protection should be increased instead of reducing the rate of nitrogen fertilization and thus preventing the yield increase.

Beke, F.: The disadvantages of nitrogen application are small compared to its important role. Apart from ensuring an optimum rate of application there are other ways of eliminating the disadvantages. The question is based on extreme cases. A harmonious supply must be ensured.

Beke, I.: The saturation of the soil with nitrogen is, in my opinion, inadmissible both for economic reasons and from the point of view of soil physiology, environmental protection and plant protection. Nitrogen, which is a highly mobile element, becomes immobile in such cases, and eventually becomes bound to the base rock and is thus lost to the plant.

The process of mobilization should be enhanced in order to make the natural nutrient content of the soil available.

From the point of view of environmental protection saturation with nitrogen is extremely harmful as it causes cation exchange and the consequent leaching of the cations.

The soil turns acid, the direction of humus formation changes, and in water a toxic minrit level develops which causes autotrophization.

It is also harmful from the point of view of plant pathology and plant protection, as it reduces the resistance of the plant.

Complex fertilizers should be produced with a rate of mobilization which corresponds to the needs of the plant in the successive phases of development.

Buzás, I.: An abundant supply of nitrogen to plants may be questionable from the point of view of phytopathology and plant protection even if the plant responds to the increasing rates of nitrogen fertilization with larger yields, and the quality of the crop is not reduced below the level of usefulness either (e.g. a high nitrate content in vegetables, etc.). This is because the application of larger amounts of nutrient may involve an increase in the costs of plant protection.

One of the causes of this, the susceptibility to diseases, is a fairly well-known fact. Much less consideration is given to the fact that the weeds also receive nutrients when fertilizers are applied. In a soil abundantly supplied with nutrients the weeds also develop better, so it requires more energy to overcome them. This is not dangerous, providing that the biomass of the cultivated plant increases as a result of higher rates of nitrogen fertilization. It may happen, however, that the given amount of nitrogen no longer increases the biomass of the crop as it falls within the saturation section of the action curve of nitrogen fertilizer. At the same time the weed plants still respond with an excessive increase of biomass to the given amount of nitrogen fertilizer; the saturation phase of their nitrogen fertilization action curve does not begin until very large quantities of nitrogen have been applied. In this case nitrogen fertilization forces the cultivated plant to enter into unhealthy competition with the weeds.

Thus, a dose of nitrogen fertilizer, even if it results in an increase in the yield of high quality crops, can only be regarded as optimum when the increased cost of plant protection does not make production unprofitable.

Since the concept of optimum rate of fertilization has been discussed in detail, I will only give a single example now to show a different situation.

If, for example there is a shortage of the given produce while nitrogen fertilizers and pesticides are available in any amount, then the optimum rate of nitrogen fertilization is that where problems of plant protection which arise can still be solved.

Debreczeni, B.: The occasional phytopathological cases occurring in relation with the nitrogen level of the soil cannot be regarded as dangerous. Today, the development of intensive and increasingly successful chemical control and integrated plant protection has reached a point where plant protection problems no longer prevent efficient nitrogen fertilization from being utilised.

Győri, D.: I think abundant nitrogen application is acceptable, as plants are unable to build up their organisms without nitrogen. It does not always increase the susceptibility of plants to diseases either; there are data to prove the opposite as well. Appropriate methods of disease control can and must be elaborated, since high yielding intensive plant varieties are more susceptible to infection by certain pathogens, if only because of the density of the stand. A reduction in the rate of nitrogen fertilization would mean a decrease in the yield level.

Haraszti, E.: It is a well-known fact that the susceptibility to diseases of plants grown on soils rich in nitrogen, or abundantly supplied with nitrogen, increases. In spite of this I think that abundant N-fertilization is fundamental and indispensable in intensive agricultural production. To reduce the harmful effects, however, intensive research is required in all fields ranging from investigations on plant physiology to the better knowledge of the development and laws of resistance, and to the establishment of new agrotechnics and plant protection based on prevention. In my opinion, complex fertilization, including certain necessary microelements, will play an important role in preventing or reducing the harmful effects mentioned.

Harmati, I.: In my opinion, an abundant supply of nitrogen to the soil and the plant is dangerous, for example from the point of view of phytopathology and plant protection. In agrotechnical experiments with wheat a close correlation was found between the extent of infection by fungal diseases, particularly by powdery mildew, and the rate of nitrogen fertilization, that is, the larger the amount of nitrogen applied, the more susceptible the wheat variety and the denser the stand, the greater was the extent of infection. This often led to lodging and grain shrivelling. Increased care must be taken in supplying nitrogen to wheat varieties which are particularly susceptible to diseases.

This harmful effect of nitrogen can be mitigated by optimum rates of fertilization, by establishing a proper ratio of NPK in the soil, and by divided fertilizer application adapted to the nitrogen uptake of the plants.

It should be noted, however, that the concept of much or little nitrogen is considerably influenced by the precipitation conditions.

In long-term fertilization experiments an excess of nitrogen in the soil and an incorrect NPK ratio were found to result in a more rapid multiplication of soil-borne pests. This may be the source of further serious damage which raises the cost of plant protection. Statements of this kind have not been encountered in the literature so far.

An excess of nitrogen in the soil may have further harmful effects:

— The plants may contain a dangerous amount of NO_3.

— The root system will be smaller.

— The vegetation period will be prolonged.

— Problems of environmental protection may occur: the nitrogen contents of run-off and groundwaters may increase.

Since nitrogen is the most important plant nutrient, it is very important to use it in the right amounts and in the correct distribution if large yields are to be attained. However, the optimum rate of nitrogen fertilization can only be determined approximately, as it depends on the moisture content of the soil as well as on the nitrogen requirement of the plant. The efficiency of the nitrogen is greatly influenced by the water level of the soil. The optimum amount of nitrogen is lower in moist soils and higher in dry ones. Thus, if the nitrogen content of the soil is high, great damage can be done to the wheat in a rainy period. So the amount of nitrogen to be applied should be determined on the basis of the requirement of the plant, the soluble N-content of the soil and the water content of the soil. When the soil is soaked with water to a deep enough level, and contains nitrogen in quantities exceeding the total nitrogen requirement of the wheat, then further top dressing should not be carried out, at least not until the plant begins to shoot. I think it expedient to apply 50—60% of the necessary amount of nitrogen in the autumn, in the form of basic fertilization. The rest should be distributed in the spring in the form of top dressing on one or two occasions, according to the nitrogen and water content of the soil, the nitrogen-supplying capacity of the soil, and the development of the wheat.

HUSTI, M.: The amount of nitrogen to be supplied to the soil is determined by the soil itself, the climate and the requirements of the plant. If there is an abundant nitrogen supply the disease resistance of the plants is reduced and their susceptibility increases, so the excessive application of nitrogen must be avoided. When nitrogen is supplied above the required amount the quality of some crops deteriorates (e.g. sugar-beet, spring barley). The nitrogen demand varies with the development phases of the plant. A knowledge of this is very important if nitrogen is to be supplied economically but nevertheless successfully. Nitrogen application in isolation from other macro- and microelements is not expedient.

KISS, A. S.: Nitrogen fertilization is indispensable. As regards the relationship between the disease resistance of plants and the rate of nitrogen fertilization the literary data are contradictory. On the basis of our experimental results I am of the opinion that even a high rate of nitrogen fertilization, when it is combined with phosphorus, potassium, magnesium and various microelements, will increase disease resistance rather than decrease it. On these grounds I am all for a high rate of nitrogen fertilization provided it is applied in proportion with other nutritive elements.

KISS, Á.: An excessive supply of nitrogen to the soil cannot be approved of because of the phytopathological and plant protection problems this raises. In addition, it is harmful from the point of view of environmental protection. On sandy soils excessive nitrogen fertilization represents a serious danger to human and animal lives because of the high nitrate and nitrite content of the drinking water.

KOLTAY, Á.: An abundant supply of nitrogen alone to the soil and plant is known to increase the susceptibility of the plant to diseases, deteriorate the quality (especially in the case of industrial crops), and cause lodging, thus leading to yield losses in cereals. At the same time, an adequate level of nitrogen throughout the growth season has a decisive role, so nitrogen must be applied with the greatest possible accuracy in amounts covering the requirement of the crop. In determining the economical rate of fertilization the nitrogen-supplying capacity of the soil, the pre-crop and the possible after-effect of fertilizers previously ploughed into the soil must be taken into consideration, as well as the requirement of the plant.

Kováts, A.: No categorical answer can be given to the question, if for no other reason than that the term abundant supply may be used to mean either a too high or a sufficient rate of nutrient application. It should be mentioned that nitrogen plays a very important role in determining the size of yield, though the significance of a harmonious nutrient supply should also be emphasized. In some crops the overapplication of nitrogen has an unfavourable effect on the quality (e.g. malting barley, sugar-beet, fibre crops, etc.), while in others an abundant supply of nitrogen improves the quality (e.g. wheat). In green fodder crops and vegetables it may cause an unfavourable nitrate accumulation. A high rate of nitrogen fertilization is not desirable from the point of view of environmental protection either. It must be emphasized, however, that without a proper supply of nitrogen satisfactory yields cannot be expected, so crops with high nitrogen requirements must continue to be supplied with this nutrient even if there are reservations from the point of view of plant protection. Larger yields call for due preparations on the part of plant protection experts.

Kükedi, E.: An abundant supply of nitrogen to the soil, as long as it is economical, is justified from the point of view of phytopathology and plant protection, provided a parallel, harmonious replacement of phosphorus and potassium is also ensured. Disproportionate rates of nitrogen, on the other hand, are unacceptable for various reasons. An excess of nitrogen increases the susceptibility of the plant to diseases. From research results and practical experience it is known that the degree of infection by *Erysiphe graminis* DC f. sp. *tritici* Marchal, *Cercosporella herpotrichoides* Fron., *Fusarium* spp. and *Puccinia* spp. is substantially greater in such cases than when the plants are given a balanced supply of NPK.

There are also other disadvantages of an overapplication of nitrogen: it increases the liability of cerals to lodge, makes mechanical harvesting difficult, and even renders the economic efficiency of fertilization questionable. Excessive nitrogen fertilization reduces the sugar content of sugar-beet and the storability of potatoes and of many other horticultural crops.

Safe rates of nitrogen and their limits are difficult to determine, as they are influenced by many factors. For the two most important field crops in Hungary (wheat and maize) rough values can nevertheless be given. In wheat, for example the present upper limit is about 150—160 kg/ha nitrogen. And on very dry areas, after pre-crops with unfavourable after-effects, which leave a large mass of roots behind, in varieties with high standability, which are less inclined to lodge and less susceptible to diseases the upper limit is 180 kg/ha.

In maize grown on chernozem-type soils the present limit is about 160—180 kg/ha. For record yields as much as 200—220 kg/ha nitrogen active agent can be distributed, provided a parallel, harmonious PK supply is also ensured.

All in all, an abundant nitrogen supply is advantageous, but one-sided, excessive nitrogen fertilization is, for various reasons, harmful.

Láng, G.: Experimental results show that nitrogen fertilization is the most economical when the demand of the plant for this nutrient is optimally satisfied. An amount of nitrogen in excess of this is usually unnecessary wastage, and may even cause a depression in the yield. To supply less than that, on the other hand, is not expedient because then the manifestation of other yield determinants is prevented and the yield will be lower than optimum, whereby the cost per unit product will increase. The optimum satisfaction of the nitrogen demand of plants very often increases their sensitivity to the environment (drought, diseases and pests, etc.); intensive nitrogen fertilization must therefore be combined with thorough disease control and the application of cultural practices suitable for reducing the adverse effects of environmental factors.

Lőrincz, J.: The optimum curve can be influenced by many factors. This may affect the daily price trend, which may, however, be significantly changed by the soil-plant-nutrient level. The nitrogen supply of the soil in Hungary is anything but abundant. Different species and varieties have widely differing nitrogen requirements, but with a low nitrogen level large yields are inconceivable. Quality is another question. If quality replaces quantity as the basis of acceptance, and thus of profitability, then it may easily become possible to reduce the rate of nitrogen application. The response of the plant to nitrogen fertilization can be changed by breeding, but a higher rate of nitrogen supply need not be feared due to the increased plant number per hectare and the expected quantity of yield either.

MIHÁLYFALVY, I.: Apart from other aspects, abundant nitrogen application is dangerous because it results in water (above all in drinking water) pollution. Owing partly to the natural, but more particularly to the man-made circulation of water, water pollution and the need for efficient protection against it is becoming a more and more urgent problem. The various contaminating agents which get into surface waters upset the biological equilibrium and destroy aquatic organisms, thereby robbing them of their ability for self-purification. Contamination primarily threatens the water in reservoirs, but has other consequences as well. In farther reaches of the given waterway the contamination disturbs the water supply of the population, industry and agriculture alike.

MOLNÁR, F.: Present fertilization practice and long-term fertilization experiments prove that the amount of nitrogen which can be applied determines the attainable yield in almost all crops to about 70%. Therefore, nitrogen must definitely be supplied up to the optimum level of nitrogen utilization.

An overapplication of nitrogen may be harmful in certain crops. Personally I have observed this mainly with wheat and sunflower. These plants respond to excessive nitrogen fertilization with reduced disease resistance; lodging and the consequent appearance of various fungi occur in wheat (*Ophiobolus graminis*, *Cercosporella herpotichoides*, *Fusarium* sp., etc.). In sunflower deficient seed setting and various diseases are encountered *(Botritis cinerea, Plasmopara halstedii)*. In other field crops the overapplication of nitrogen is not dangerous, as for as I can see; in droughty years it may even have a positive effect. Owing to the physical state, the form of packing and the distributability of the nitrogen fertilizers available at present and to the poor quality of Hungarian fertilizer distributors certain parts of the topsoil do not receive sufficient nitrogen. This causes a reduction in yield, thereby causing greater damage than excessive nitrogen fertilization could cause.

In 1978 a higher rate of nitrogen utilization in the form of complex fertilizer (15 : 15 : 15) did not cause lodging in wheat; the hl-weights of our wheats (Libellula, Jubileinaya, Novosadska Rana, MV 4) was highly favourable, and harvesting was completed without loss in spite of the unfavourable weather conditions. 180 kg/ha fertilizer with the above composition was applied in the form of top dressing, and this amount ensured 5 to 7 q/ha surplus yields compared to the control, at a yield level of 58 q/ha.

MOLNÁR, J.: The economicalness of nitrogen application must not be judged in isolation from P_2O_5 and K_2O. Fertilization in Hungary is mainly characterized by an over-application of nitrogen, or an insufficient supply of potassium and phosphorus to the soil. An absolute or even relative overdominance of nitrogen makes the plant susceptible to pathogens, which impairs the quality of the crop and may cause considerable yield losses too.

Susceptibility to pathogens appears as an adverse effect of an excessive nitrogen supply. In practice on the Bácsalmás State Farm, for example, a 1 : 1 : 1 NPK ratio is considered desirable in wheat production. An excess of nitrogen in wheat involves a greater danger of powdery mildew and Fusarium infection. The Bácsalmás Sunflower Production System sets out a 1 : 2 : 2 ratio for sunflower, and in sunflower seed production nitrogen is not used at all. This technology takes into consideration the fact that sunflower is highly susceptible to pathogens; resistant varieties and active plant protection methods are not known.

NYÉKI, J.: There is no doubt that the growth of plants can be influenced most efficiently by nitrogen fertilization. It is a well known fact that nitrogen applied in excess has a very adverse effect on the value of the components, particularly in crops producing roots or tubers full of juice. Economic calculations prove that the absolute weight increase does not give unambiguously favourable results.

The losses, provided the crops are evaluated by quality, are partly felt on the farm itself (lower delivery price, increased costs of transport), but at a national economy level they are felt in industry too, since the manufacturing costs rise.

There is, however, another danger which is not considered very seriously at present. With an overapplication of nitrogen NO_3 may be incorporated into the plants causing serious problems in humans and animals alike.

PAIS, I.: I consider that an abundant supply of nitrogen in the soil is harmful not only from the point of view of phytopathology and plant protection but also as regards environmental pollution and economy. I feel that a "luxurious" supply of any nutrient to the soil is uneconomical and generally incorrect.

PECZNIK, J.: It is a well known fact that nitrogen is a component of organic compounds of vital importance (proteins, nucleic acids, chlorophyll, etc.), and the available nitrogen content of the soil is often a limiting factor in yield formation. The history of European agriculture proves that a substantial increase in the yield averages of crop production has only ever occurred with nitrogen added to the nutrient turnover of the farm from external sources (through the production of papilionaceous crops or the utilization of nitrogen fertilizers). An adequate nitrogen level in the soil is still one of the most important, though naturally not the only, precondition for attaining large yields. The physiological balance between plant nutrients is a concept which has been known and used for a long time, but it has still not been satisfactorily adapted to actual site conditions and crops. There can be no doubt that abundant one-sided nitrogen fertilization may result in harmful consequences: the resistance of the loose tissues to pests decreases, and in some cases the chemical composition of the crop undergoes an unfavourable change (e.g. the sugar content of sugar-beet may be reduced, nitrate may accumulate in the plants, etc.). The lower resistance of the plants involves increased plant protection, generally a higher rate of pesticide application which, owing to pesticide residues, raises problems in the fields of environmental pollution, feeding and nutrition.

The use of unreasonably large volumes of nitrogen fertilizer may in itself cause environmental pollution (e.g. nitrates are washed into the groundwater or carried into natural surface waters due to erosion, etc.). Our own investigations have proved that if the plants are analysed the optimum nitrogen level can be determined to a good approximation. In experiments with wheat, for example, a negative correlation was found between the nitrate content of the wheat grain and the quantity and quality of the yield.

PETRASOVITS, I.: Both Hungarian and international experiences prove the generally outstanding role of nitrogen fertilization. Nevertheless, in many cases an abundant nitrogen supply cannot be judged only from a phytopathological or plant protection point of view. It may be dangerous, permissible or right, depending, among others things, on the variety, the production aims, the level of plant protection, and finally on the numerical value of the "abundant supply".

POZSÁR, B.: A better knowledge of yield components may result in the improved conversion of nitrogen fertilizers without increasing the degree of pathological damage. For example, when CCC is supplied the yields of wheat and barley can be increased by another 30%, without any significant grain loss at harvesting due to the higher rate of nitrogen fertilization. Ammonium nitrate should be replaced by carbamide or ammonia as soon as possible because of the harmful effect of nitrate. Nitrate and nitrite levels are dangerous because of their toxic effect on humans rather than due to the increased pathological susceptibility they induce in plants; the latter can gradually be corrected by breeding for resistance and using up-to-date fungicides.

SEMJÉN, I.: Under Hungarian conditions nitrogen fertilization is the primary determinant of yield. The soils of our farm are well supplied with phosphorus, potassium and microelements for quite a long time ahead, as they have been saturated with these nutrients. Nitrogen cannot be supplied in quantities which are sufficient for a long period, but even in the short term the quantity applied, the date and method of application and the physical state of the nitrogen fertilizer are, like other production and natural conditions, determinants of the quantity and quality of yield.

Taking all this into consideration, I think it is important to supply the plant with sufficient nitrogen to safely cover its needs, even if this means that its susceptibility to disease will increase. In the latter case increased attention should be paid to plant protection. Greater care must be taken in choosing the varieties to be grown so that they should be resistant, or at least tolerant to various fungal diseases, *Fusarium*, etc. If plant protection is properly organized more serious damage can be prevented today in most cases, because better and better chemicals, aircraft and helicopters are all available, and are extremely useful when handled by experts.

More and more plant varieties are available to the farmer, which, if they are not resistant, are at least tolerant to diseases, provided plant protection regulations are strictly observed.

Thus, nitrogen fertilizers should be used in quantities which will produce maximum yields even if this involves an increase in plant protection costs and requires greater care in choosing the varieties to be grown, because these latter are not in proportion with the greater production value, i.e. the higher returns, which can thus be achieved.

Shmilliár, M.: Excessive one-sided nitrogen fertilization involves a great risk, or may even be said to be harmful. Yet, when nitrogen is supplied in the proper ratio it is of very great importance. A healthy, well developed, but not overgrown, plant has a higher yield ability than plants with average or poor development. This statement also applies to those crops whose belowground yields are of primary importance. The plant protection aspect of the question is less significant than it was before, as the high level of disease control and the multitude of pesticides offer wide possibilities for keeping the crops healthy.

Szalai, Gy.: The nitrogen supply should be increased as long as it results in a yield increase. As soon as it no longer increases the yield owing to the decreased resistance of the crop to diseases, the rate of nitrogen fertilization should be reduced. Another aspect of the question is the role of resistant varieties, which assume greater importance as fertilizer utilization is increased and render it possible to use larger doses of nitrogen.

Szalay, S.: A rate of fertilization far above that required for a balanced supply of nutrients cannot be approved of for both energetic and other reasons. On the other hand, the nutrients extracted by the crops in each vegetation period must definitely be replaced. However, not only nitrogen, potassium and phosphorus should be considered, but in the case of poorer soils magnesium, calcium and sulphur should also be replaced as well as the micronutrients, where this is necessary.

Szeniczey, Cs.: Excessive nitrogen application is already a current problem. The loose tissues of an "overforced" plant are phytopathologically susceptible. The troubles caused by a one-sided abundance of nitrogen are rapidly accumulating.

The superfluous use of nitrogen and the increasing costs of plant protection involve extra expenses. Protracted harvesting due to delayed maturing causes considerable losses, problems related with feeding become greater, and the loss during storage increases by leaps and bounds.

Székessy-Hermann, V.—Fazekas, S.: An abundant supply of nitrogen to the soil is, in our opinion, dangerous, not only for the reasons mentioned, but also because it upsets the stability of the ecological system in the soil, which sooner or later results in a yield depression. It is perhaps an even more serious argument that plants grown on such soils may be harmful to the animals that feed on them, and directly or indirectly to man. There have been examples in Hungary of expert, excessive applications of fertilizers having an adverse effect on the marketability of the product (e.g. in apple growing).

Tompa, Gy.: The plant, like any living organism, cannot exist without nitrogen, as the latter forms an indispensable part of all its protein-type compounds (enzymes, vitamins, chlorophyll molecules).

The plant gives clearly visible signs of nitrogen deficiency. The leaves turn yellow, the vegetative organs remain underdeveloped, and if the nitrogen shortage increases it may result in the death of the plant.

The plants respond quickly when nitrogen is supplied, since the incorporation of nitrogen occurs rapidly and has a more conspicuous effect than that of either P_2O_5 or K_2O.

It is thus obvious that the nitrogen supply is a very important criterion of agricultural production and is indispensable in programmes related with increases in yield.

What frequently causes problems is the incorrect practice of supplying the plants with too much nitrogen after the initial phase of development as a consequence of one-sided nitrogen fertilization. Due to the disturbance of the nutrient balance various phytopathological problems arise, because the sudden growth of the vegetative organs results in the loosening of the tissues.

The effect of one-sided, excessive nitrogen fertilization is felt even in the soils, because a considerable proportion of the soils in Hungary are poor in phosphorus, and in the absence of phosphorus nitrogen alone is not able to increase the yield.

It is therefore evident that nitrogen must always be supplied is such a way as to maintain the nutrient balance.

TULCZ, I.: I think it is very misguided to give priority to phytopathological and plant protection aspects over nitrogen fertilization. The question of nitrogen fertilization has often been discussed lately from this point of view. I am convinced that we use less than the practicable amounts of nitrogen fertilizer precisely because of such opinions.

It cannot be emphasized too often that under the dry climate of Hungary a higher rate of nitrogen fertilization is of increased importance.

It is up to the breeders to produce varieties resistant to diseases and both tolerant and responsive to large amounts of nitrogen.

It is the task of plant protection to develop the right technology for fighting off plant diseases.

To sum up, I am all for an abundant nitrogen supply and this view is confirmed by farming experience over the last few years, when, in spite of the dry weather, we had larger yields than other farms due to the higher rate of nitrogen fertilization.

*

PÁL, GY.: **As a result of intensive agricultural cultivation 50 q/ha maize (calculated in shelled May corn) and 35 – 40 q/ha wheat are harvested in Hungary on a national average, and with these yields large quantities of microelements (Fe, Mn, Cu, Zn, Mo, B, Co, Si, Cl^-) are also removed from the fields. Under the geographical and geological conditions in Hungary, do you think that shortage of microelements need not be reckoned with, or that after some time a deficiency may occur, or that they should already be replaced in the soil or through the leaves of the plants?**

ÁCS, A.: There is indeed, a danger that overdoses of macronutrients (N, P, K) will upset the nutrient balance of the soil and result in an absolute, and more probably in a relative reduction in the amount of microelements. As a consequence, there may be a sharp decrease in the level of microelements in the soil, and a change in the chemical composition of the plants may also occur. This change in composition may disturb the physiology of the plants, and when the plants are used for nutritional purposes (as food or fodder) this may give rise to "deficiency diseases". Thus in order to endure a proper balance, the microelements should definitely be replaced, either in the soil or through the leaves. Further research work is needed to determine the microelement requirement and the method of application for each crop.

BARACS, J.: In soils formed on loess as base rock in Baranya county no particular decrease in the microelement content has been observed; microelement deficiency is of increased importance in the case of sandy and clayey soils, because of its influence on the yield.

There is evidence that a regular application of organic manure prevents any essential decrease in the microelements. Microelement deficiencies must, however, be reckoned with in meadow and pasture farming. In this context I suggest that the screening tests carried out at the Agricultural College in Kaposvár should be taken into consideration.

BAUER, F.: With large yields and the substitution of fertilizers for farmyard manure the occurrence of microelement deficiencies must be reckoned with. The determination of the necessary and economical extent of microelement replacement is primarily, however, a research task. Priority should be given to investigations which will provide reliable information on the extent of the deficiency of each microelement required for the balanced nutrition of plants and the increase of yield averages. This is necessary because the scientific foundation of plant nutrition with the microelement mixtures currently available leaves much to be desired.

BEKE, F.: The replacement of microelements is now becoming topical. Farms which have harvested large yields for many years have already realized the necessity of microelement replacement. The role of the meso-elements is also becoming more apparent, as the supply of these is also decreasing in certain soils.

Beke, I.: A shortage of microelements must be reckoned with today under Hungarian conditions and measures should be taken to make microelements available whenever they are needed by the plant.

If application or replacement is to be carried out action dynamics curves will be needed. At present foliar nutrition is the best known and most widespread method of supplying or replacing meso- and microelements.

Buzás, I.: Deficiency diseases caused by a shortage of microelements are encountered more and more frequently in Hungary, as elsewhere. Where these diseases are found the microelement deficiency must naturally be made up for.

It is very important to establish a network of laboratories capable of detecting the microelement deficiency even before the symptoms appear, thus making prevention possible. Furthermore, such a network of laboratories would make it possible to put an end to the present situation in microelement nutrition, which can best be compared to charlatanism.

The overwhelming majority of the microelement fertilizers available do not suit the future aims. These preparations contain a full range of microelements but each is present in too small a quantity. If a deficiency of one or other microelement, e.g. boron, occurs, a complex microelement fertilizer has to be applied for lack of special boron fertilizers. By doing this we supply the plant with microelements that it does not require, while the desired element is not provided in a quantity sufficient to put an end to the deficiency disease.

Another condition for rational microelement replacement, besides the network of laboratories to detect microelement deficiencies, is the availability of special microelement fertilizers containing certain microelements in high concentrations.

When using micronutrients one must not forget that a considerable part of them are heavy metals which tend to accumulate in various plant and animal organs, while in high concentrations they are very strong cell poisons.

The alfalfa plant gives a yield response to increasing rates of molybdenum nutrition even when the molybdenum content of the young shoots is already toxic to the animal organism.

Debreczeni, B.: Research on the microelements has only been carried out for a relatively short time in Hungary, so there is very little data available on the microelement supplies of plants in different soil types. It is certainly true that the more intensive the NPK fertilization, and consequently the increase in yields, the more urgent the replacement of microelements, since larger yields extract higher quantities of microelements from the soil.

Our present knowledge also confirms the enormous biological importance of microelements in up-to-date crop production. However, when speaking of the microelements it should be noted that, while they are very useful or even indispensable in small quantities, they may be cell poisons and have toxic effects in larger amounts. It must be emphasized that the toxic effect of some microelements is close to the optimum level, and a higher amount of some of them may cause disturbances in the animal organism. Microelement application therefore requires great care and circumspection. But in the case of most microelements, deficiency occurs more often than toxicity in practice. Both should be avoided as they may lead to many undesirable consequences.

The quantitative (yield-increasing) effect of the microelements is generally much lower than that of the macroelements (NPK), but they are of considerable importance in improving the quality (e.g. increasing the sugar content) and frost hardiness of crops, in promoting their resistance to diseases, etc.

The microelement requirements of plants are still recognised mostly from certain known deficiency symptoms. The quantitative microelement demand is determined by the microelement content of the product. Soil and plant analyses are equally important means of determining the actual demand. In the course of microelement replacement attention should be paid to the fact that the simple fertilizers, particularly superphosphate and calcium ammonium nitrate, contain relatively large quantities of microelements, particularly manganese, zinc and copper. With a high rate of fertilization the amount of microelements thus supplied may well prove to be sufficient for the time being. The rate and method of microelement replacement are determined by the fact that the quantity of microelements extracted by the plants is very small, altogether 5—400 g/ha. It is almost impossible to distribute such a small amount and plough it into the soil, so the active ingredient is either mixed with a carrier, or a new, more suitable method of fertilization is developed and used. Both solutions are used. The trace element fertilizers may be water-soluble salts, or they may be mixed with a carrier such as another fertilizer, some kind of industrial by-product, a chelating material, or silicate glass. But a much more effective and economical method of microelement fertilization has been developed: this is the application of low concentrations (0.02—0.5%) of nutrient through the leaves (spray fertilization).

GYŐRI, D.: A shortage of microelements must already be reckoned with in Hungary even under the present conditions. Owing to the unfavourable soil properties microelement deficiencies occur even when microelements are found in abundance in the soil. Microelements must be supplied because of their influence on the quality of the crop. A high rate of phosphorus fertilization, for example, decreases the zinc and tryptophane contents of maize. In a soil badly supplied with zinc a 10—30% deterioration of quality may occur. In the case of unfavourable soil properties microelements can be supplied through foliar spraying.

HARASZTI, E.: In proportion to the amount of nitrogen effective substance used, and depending on the genetic origin of the soils, the replacement of various microelements may already be necessary for certain regions, soils and crops. The method of application is determined by the structure and quality of the soil and the kind of crop to be grown. While the application of microelements through the leaves of the plants is found almost unequivocally to be the best method in fruit growing, in the production of field crops, especially fodder plants, the practice of nutrition through the soil has proved better. The method of application is naturally determined fundamentally by the forms of microelements available. For example, manganese mud can only be applied through the soil on manganese-deficient areas.

HARMATI, I.: Unfortunately, not enough is known yet about the microelement content of Hungarian soils. It cannot be properly judged on the basis of the available data. In my opinion, much greater importance should be attached to research on this problem. In many places the available microelement contents of the soils are certainly not sufficient to produce high yield averages. This depletion is most likely to occur in places where:

— large doeses of fertilizer have been applied for a considerable length of time,
— irrigated crop production is practiced,
— monocultural (single-crop) production is carried out,
— this necessarily follows from the genetic properties of the soil.

As I see it, microelement deficiencies must already be reckoned with at the present level of fertilization, and the replacement of these elements is necessary. In experiments carried out with wheat and maize favourable results have been obtained. In my experience the effect of microelements introduced into the soil is less reliable than it might be because they become fixed. Intensive research is needed to clear up these problems.

HUSTI, M.: According to the geographical and geological data the micronutrient deficiency in Hungary varies.

Some regions, such as Somogy county, the region between the Danube and the Tisza, etc. already show signs of microelement deficiency, as is also indicated by the yield levels.

The microelements extracted from the soil have not been replaced for centuries, particularly over the last 30 years, since larger amounts of artificial fertilizer have been substituted for farmyard manure.

It is now thought that small quantities (60—80 q/ha) of farmyard manure should be supplied every 2 or 3 years to intensify the biological functions of the soil and thus to ensure the availability of the microelements to the plant. Besides this, microelement application on the basis of local observations and laboratory analyses seems to be one of the basic conditions for increasing the yield.

A knowledge of the symptoms is highly important for the farm, as temporary deficiencies occur in the plant in the course of the vegetation period which may be due to a drop in temperature, lack of rainfall, etc. In such cases analyses do not demonstrate any deficiency in the soil, yet the plant is unable to take up the nutrients. Macro- and microelements supplied through the leaves help the plant through the critical phase.

KISS, A. S.: A relative deficiency of microelements must already be reckoned with. With increased fertilization this deficiency will continue to grow, as the available microelement supplies are already beginning to run out, as proved by the good results attained by applying microelements as leaf spray. I think that microelements can only be successfully applied through the foliage, because in sandy soils they are washed out, while in clay they become unavailable to the plants because adsorption is too strong.

KISS, Á.: Intensive agricultural cultivation produces very large yields, which will increase still further. The replacement of the microelements extracted from the soil is already necessary. Agrochemical investigations will give a precise determination for each crop and soil type of the kind and amount of microelement to be supplied through foliar or root nutrition. A knowledge of the interactions between microelements will be important here.

KOLTAY, Á.: The need to supply Ca and Mg besides the regularly replaced macroelements has been demonstrated for certain soil types in Hungary. It is time the role of the microelements was clarified, because the intensity of field crop production and the increasing use of macronutrients make the occasional application of certain microelements necessary. According to our present knowledge the microelements which are known to have biological actions (sulphur, iron, copper, manganese, boron, zinc, molybdenum, cobalt, chlorine, sodium, silicon vanadium) are most likely to need replacing. In most soils at the present level of nutrient supply the effectiveness of microelement fertilization has not yet been demonstrated. The symptoms of deficiency should be identified, the microelement contents of the soils should be determined, and deficiencies which may already occur under given conditions and plant/soil relationships should be demonstrated. The simplest way to make up for the deficiencies found seems to be the use of complex fertilizers enriched with microelements. In experiments at Martonvásár the efficiency of microelements (zinc, copper, iron, manganese, titanium) sprayed onto wheat has not been proved so far.

KOVÁTS, A.: The plant needs more nutrients to increase its yield. This applies not only to the macro- but also to the microelements. Under Hungarian conditions at the present level of production, microelement deficiencies in field crops are only sporadically encountered, e.g. zinc deficiency in maize after reserve phosphorus application, or lack of boron in sugar-beet grown on calcareous soil. Under Hungarian conditions microelement deficiencies need not generally be reckoned with as yet. Except in a few cases experiments have not shown any significant effect from microelement application either. It must be kept in mind, however, that as a consequence of the high rate of macroelement supply and the constantly increasing yields, sooner or later a microelement deficiency may occur in the soil, and steps should be taken now to counteract this. The amount of secondary elements found in the aggregates of Hungarian fertilizers and the use of farmyard manure do in fact mean that certain micronutrients are partially supplemented.

In my opinion the need for microelement supply will not become urgent until the 1990s. Eluviated sandy soils may be an exception where the replacement of microelements will become necessary at an earlier date.

KÜKEDI, E.: Microelement deficiencies of a local character occurred even in the past. Symptoms of microelement shortage are often encountered today, but for lack of exact experiments the frequency of their occurrence and the extent of the losses caused by them would be difficult to determine. The replacement of microelements is likely to become increasingly necessary, as the microelement content of the soils will decrease owing to the large yields. There is, however, another point of view from which the replacement of trace elements is important. According to the results of investigations made by Schütte in the German Federal Republic, for example, the lack of copper and boron increases the degree of infection by powdery mildew. A relationship between microelement deficiencies and pathogenic fungi is likely to exist in other crops too.

Information on the microelement contents of soils is given by the results of soil analyses. If the amount of magnesium, for example, contained in light soils is less than 3 mg/100 g soil, then the deficiency must be made up for. In heavy soils the limit for replacement is 8 mg. Data on other microelements are also found in the tables. By taking these tables and the results of soil analyses into consideration we can decide whether or not replacement of microelements is necessary.

The simplest way of carrying out trace element fertilization is to use fertilizers which are enriched with microelements. These have the great advantage of covering the requirements of the plants for a long time. This well proven method is regularly employed in the western countries. Having a wide range of microelement-enriched fertilizers they have no difficulty in choosing the most suitable ones. In Hungary the assortment is not yet as wide. It is not by chance that in Hungary trace elements are also replaced by foliar nutrition. Spray fertilizers are also used in horticultural crops and orchards. The third method of microelement replacement is the use of microelement fertilizers and preparations produced for this special purpose.

It can thus be seen that the replacement of microelements is already necessary today. Replacement can take place through the application of microelement-enriched fertilizers, spray fertilizers containing trace elements, or individual microelement preparations manufactured for this special purpose.

LÁNG, G.: The microelement content of the soils available to the plants is not yet known. Investigations are being carried out on this subject. With increasing yields the microelement requirements of the plants will obviously grow. The microelements will consequently be reduced to a minimum sooner or later. Preparations must therefore be made for microelement fertilization in both ways: through the soil and through the leaf. Just as in the case of macroelements, a fertilization system must be elaborated for the microelements.

LŐRINCZ, J.: A yield of 50 q/ha for maize and 40 q/ha for wheat will not be enough for profitability even next year, so the yield per ha must be increased from year to year, and this will require an adequate quantity and composition of microelements. The missing microelements can be replaced in various ways. Microelement deficiencies can be successfully made up for through the leaves and in the form of chelates worked into the soil.

In the case of the 80 q/ha wheat, 90–100 q/ha maize or 100–130 q/ha alfalfa hay produced by the production systems the regular replacement of certain microelements is necessary even now. Symptoms of deficiency have already appeared in several places and crops.

MIHÁLYFALVY, I.: Apart from the macroelements the microelements are also of great importance if large yields are to be obtained. In sugar-beet, for example boron, manganese and zinc deficiencies may result in severe infections caused by viruses, cercospora and other pathogens, thereby threatening both the quantity and quality of the yield. In my opinion the microelements should be replaced primarily through the soil by applying complex or mixed artificial fertilizers.

MOLNÁR, J.: The fact that yield analyses of large yields show deficiencies of microelements suggests that there is a shortage of these elements. This means that the microelements should be replaced very soon. Attempts are being made by the Hungarian fertilizer industry to produce fertilizers which contain the major microelements, if possible in different proportions to suit the conditions of the different regions. At present foliar nutrition by aircraft is almost the only way to supply microelements.

The regular application of farmyard manure alleviates this problem.

NYÉKI, J.: If our expectations come true, and yields increase as much as we hope they will, in some soil types a shortage of microelements must naturally be expected. In acidic sandy soils deficiencies of boron, molybdenum and copper have already been demonstrated even at the present yield levels, and similar problems are mentioned in the literature with regard to alluvial soils. The symptoms of microelement deficiency may not be noticed at first in plants, but in another link of the nutrient chain: in humans or animals. For this reason I think it is reasonable to take preventive measures. This should not be difficult since the introduction of leaf and fruit analyses, which are already widely used. Foliar application definitely seems to be the most practicable, since it does not present any particular difficulty to the farm, as the distribution can be combined with other plant protection operations. I particularly advise this solution as a lot of experimental data are available to confirm the effectiveness of foliar nutrition.

PAIS, I.: I am quite convinced that the subject of microelement management is of interest in much wider circles than those mentioned in the question, since it is of interest not only in relation to soil and plants, but also from the point of view of animals, including man, as the last "link" in the food chain. I should like to emphasize my opinion that the question of micro-nutrients should be urgently studied by a large scientific body including nutrition experts, veterinarians, agriculturists, chemists and biologists, before irreparable mistakes are made.

Objective research data show that the replacement of micro-nutrients must begin at once. With a few exceptions these should not be applied to the soil, because there they become fixed as practically insoluble compounds; the correct manner of replacement is by means of foliar spraying. In my opinion, the greatest danger at present is not the reaching of toxic levels (though we must be on our guard against this too), but the ever decreasing supply of major micro-nutrients to animal and man alike, the consequences of which cannot yet be foreseen.

PECZNIK, J.: The most important elements occurring in plants are found along the line drawn from carbon to argon in the periodic table, the so-called nutrient line. In general, the farther from the mentioned line an element is, the less necessary it is to the plants. The structural elements (C, H, O, N, etc.) have small atomic volumes, and their biological functions are closely related with this property.

Investigations made during recent decades have revealed, however, that besides the major structural elements numerous further elements are required for the smooth functioning of plants. According to Vinogradov a certain quantity of every known chemical element is present in the organs and tissues of plants. A demonstration of this has been made possible by the continuous improvements in analytical procedures. On the other hand, no convincing proof has so far been given of which elements found in plants are indispensable and which are accidental contaminations. Indispensability is disputable even in the case of certain macroelements (Si Cl), and is even more difficult to determine for the microelements. It is generally thought that elements whose shortage or absence cause deficiency symptoms in the plant are indispensable for the plant and that these symptoms can be eliminated by the application of the element concerned. The question is, in fact, much more complex, as many other circumstances must also be taken into consideration when judging the role of the individual elements (ion antagonism, re-utilization, desorption, etc.).

The biological and physiological effects of the microelements are extremely varied. Many of them are component parts of enzymes, vitamins and hormones, and thus play an indirect but important role in controlling the life processes. Their positive effect is, however, only felt between certain concentration limits, since most of them are cell poisons and may thus be toxic at higher concentrations. On the other hand, it is almost impossible to establish the optimum concentration of microelements, partly because they may either weaken or strengthen the action of one another, and partly because the composition and reaction of the soil is also not without effect; the optimum concentration may even change with the plant variety. The microelement concentration in the soil ranges between fairly wide limits, and the upper limit of optimum concentration and the lower limit of toxic concentration may be very close to each other, or may even coincide.

The soil is naturally of decisive importance in supplying the plants with microelements. However, since the extent and rate of uptake depend on the distribution of the microelement ion between the soil and the plant, the solubility of compounds containing microelements (oxides, carbonates, silicates, etc.) plays an important role. The solubility of most microelements is low, especially in alkaline and carbonate soils. Thus, in evaluating the microelement supply of plants it is not enough to know the absolute microelement content of the soil; the amounts of readily available microelements must also be known. The determination of the amount of readily available nutrients is a probiem even for macroelements, and is still more difficult for microelements.

The relevant investigations show that most soils in Hungary contain considerable amounts of microelements. The rather dry climate of Hungary, the low intensity of the leaching processes, and the extensive farming methods used in the country in previous centuries certainly have an important role in this. It is obvious that with the increasing intensity of agricultural production, the amelioration of larger and larger areas by liming, and the large-scale utilization of fertilizers containing macroelements, the question of microelement replacement has necessarily come into prominence in Hungary, as elsewhere. I do not think we should wait until the microelement supplies of our soils become so exhausted that visible symptoms of deficiency appear in the plants; the replacement of microelements must be provided for now, when the microelement deficiencies are still only latent. A good example of the latter is the phosphorus-zinc antogonism which appears for example in maize production; if phosphorus is applied above a certain level a yield depression occurs owing to the formation of insoluble zinc phosphates, leading to zinc deficiency in the maize.

According to our own experiments at present the replacement of microelements can be solved most successfully and most economically with foliar nutrition. This method is, in fact, widely used in Hungary, especially in crops where foliar nutrition can be combined with chemical plant protection.

The replacement of microelements is important not only for the plant organism; it also has an impact on herbivorous animals and consequently on human nutrition as well.

Petrasovits, I.: Under dry conditions successive large yields may result sooner or later in a general shortage of certain microelements.

In the case of regular irrigation, on the other hand, a deficiency of microelements must already be reckoned with. Unfortunately, very little is known about this problem in Hungary, but it is highly probable that a relative or absolute shortage of microelements is also responsible for the lower nutritive value of the irrigated fodder crops (e.g. a copper deficiency), and in other cases for the comparatively low level of yields obtained with irrigation.

Owing to the larger yields and to the fact that it makes the microelements more easily available irrigation generally results in the microelement supplies being exhausted more rapidly than in dry farming. After a certain length of time this microelement surplus cannot be covered by natural replacement.

Pozsár, B.: Today the mesoelement magnesium is supplied as an additive in nitrogen fertilizers. Of the microelements at least five should be replaced, not only in order to increase the yield surplus but also because complex NPK exercises a quality-improving effect when it is supplemented with micronutrients. The microelements can be distributed together with pesticides, and with this economical application the protein production and reproductive ability of farm animals can be increased.

Shmilliár, M.: No general statements can be made on microelement deficiency. In the case of sugar-beet there are areas where boron deficiency can be spoken of, particularly in places where intensive sugar-beet production has been carried on for some time. Farms in the neighbourhood of sugar factories, where concentrated production takes place, must be given particular attention, because a 700—800 q/ha yield (root + leafy head) uses up the nutrient supplies of the soil one-sidedly. If in a given district there is a scarcity of some nutrient, deficiency symptoms will soon occur. When a deficiency of some nutrient occurs whether it is a macro- or a microelement, a new situation is to be reckoned with. There are areas where field crop production has been carried on for centuries, but the traditional methods of cultivation have ensured the regeneration of the soil. The yield were low, the right succession of crops maintained the nutrient balance. By leaving the land fallow, or including perennial papilionaceae or clover with grass in the crop rotation the replacement of microelements was ensured by the roots left behind and the life function or decay of the micro- and macroorganisms multiplying in the soil.

The situation is quite different today. The organic life of the soil changes under the influence of herbicides and the conditions for natural regeneration are no longer ensured. The succession of crops has become simpler; crop rotation is augmented with temporary monocultures. The production system of the farms has become highly specialized. This, however, involves the one-sided exploitation of the nutrients, both macro- and microelements, in the soil. It naturally follows that not only the macroelements but the microelements too must be simultaneously replaced. As to the method of replacement, nutrient supply to the soil solves the problem for a longer period. With this method a work process can also be saved. If rapid intervention is needed, nutrients can be supplied to the plant through the foliage. For example, heart rot and dry rot caused by boron deficiency in sugar-beet can be prevented by boron spraying. However, if boron is added to the soil in time, the disease will not occur at all. In the case of seed production this is still more important, because yield reductions caused by the disease cause severe losses to the farm.

Szalay, S.: In Hungary deficiency of microelements can be reckoned with, e.g. in poor sandy soils. "Indirect" microelement deficiency occurs in soils which are well supplied with microelements when the microelements cannot readily be taken up by the plants, that is, if they are not mobile. For example, according to our investigations peaty soils contain sufficient quantities of micronutrients, but the humic acids bind the manganese and copper through ion exchange to such an extent that the plants are deficient in these two elements. The alkaline soils of the Hortobágy also have enough micronutrients, but the alkalinity makes the copper and zinc difficult for the plants to take up, especially in dry weather. On the neutral, slightly alkaline, sodic areas of the Great Hungarian Plain a similar problem is probably to be expected. Excellent quality soils are able to supply the plants with micronutrients for a long time even at a high yield level, but if there is a high rate of fertilization and irrigation the concentration of the less mobile microelements may not reach a high enough level compared to the macroelements. A "lush green" biomass obtained with intensive macro-fertilization and irrigation may thus be poor in mineral substances (calcium and microelements), and will thus be of reduced value from the point of view of feeding. It is through the study of the soil and production conditions and the microanalysis of green plants that the amount of microelements which should be supplied through the soil and the foliage can be determined. At present the advisory service in Hungary is not developed enough to solve the problems within a few years.

SZENICZEY, CS.: Intensive crop production is restricted exclusively to the replacement of NPK, which is applied in large doses. In most cases even those trace elements found in plant residues are prevented from returning to the soil. The appearance of micro- and trace element deficiencies in livestock farming has been observed in epidemic proportions in various disorders of reproduction biological origin, in problems of gestation, and in deformed offspring which can be put down to trace element deficiencies.

Investigations have shown that these phenomena are definitely caused by deficiency diseases arising from incorrect feeding.

The missing trace elements can be replaced either in the field or in the feed. The level of fertilizer production in Hungary has forced us to choose the latter, which is a stopgap arrangement.

The development of the plant and the full display of its biologically determined potential productivity must be ensured in the field.

The implications of this question for human biology may prove to be extremely important, provided they are examined.

SZÉKESSY-HERMANN, V.—FAZEKAS, S.: Intensive agriculture definitely calls for a regular replacement of microelements, not only to cover the specific needs of the plants, but also to ensure the ecological balance of the soil. Preference should therefore be given to its introduction into the soil. As for the costs involved in the expert replacement of the microelement content of the soil, the present viewpoint of medical science should be adopted. The results of recent research suggest that changes in the level of certain microelements indispensable to the organism also contribute to the development of a number of diseases the origin of which is not yet known for certain. Consequently, modern medical science attributes the same importance to satisfying microelement requirements which are indispensable to the human and animal organism as to the vitamin supply, the importance of which is generally accepted.

TARJÁN, R.: I think that first we must get to know the microelement content of our most important soil types, and discover what method of nutrient replacement is best suited to the erosion conditions. Changes in the quantity and proportion of microelements in both soil and plant must be followed with attention, according to the annual rotation of crops. Only when we possess this knowledge can the question of replacement through the soil or the foliage of plants be adequately dealt with. Without it, unexpected and possibly irreparable errors may be made.

TOMPA, GY.: The replacement of microelements is necessary even at the present level of production. Since an attempt is being made to raise the production level partly by using increasing amounts of macronutrients, the replacement of micronutrients, which are gradually being reduced to a minimum, is justified and necessary.

The simplest method of micronutrient replacement would be to enrich the fertilizers with the necessary trace elements during the manufacturing process.

TÖLGYESI, GY.: Some people think that it is only a consequence of the improved techniques of chemical analysis that microelement deficiencies are more frequently observed today than they were in the past. Indeed, with the simplified process of analysis a multitude of earlier unrevealed cases are detected, chiefly for the purposes of research. However, a number of plant species have proved unresponsive to any amount and combination of NPK, thus suggesting an insufficient microelement supply. Everything points to the fact that the attention paid to the microelements is not restricted to the fashionable new theoretical questions which are in the centre of interest. Under the changed production conditions the role of the microelements apparently increases whether we take any notice of them or not. There are two fundamental causes for the frequent occurrence of microelement deficiency. First, for reasons of national economy the traditional crop production areas have changed. While in the traditional areas the place most suitable for a given crop was chosen by centuries of experience, in the new areas plant species which find it difficult to adapt to the local conditions have been sustained with macro-elements. The other cause was the yield increase attained by a higher rate of NPK fertilization which was not accompanied by an increased microelement supply. The result in both cases is an enormous waste of fertilizer. The effect of fertilizer doses many times larger than the amount of active agent extracted by the crop can be explained by the fact that the macroelements have supplanted the microelements in the adsorption complex of the soil, whereby the latter have become somewhat more easily available to the plant.

While under the extensive conditions of private farm management preference had to be given to the plant species most economically grown in a given region, today we are often forced to leave this principle out of consideration in order to be able to satisfy the demands. For example, with a view to increasing the protein resources the alfalfa areas should be increased in Hungary. The alfalfa plant, which favours meadow soils rich in calcium, has low productivity and is short-lived on transitional or forest soils. With a high rate of nitrogen fertilization, which is unusual in alfalfa production, it survives somehow or other, but in spite of the higher costs the yields remain far below the level attained on typical alfalfa soils. Let us see what microelements are likely to cause these differences.

According to the results of investigations carried out in 1969 the essential difference between the zonal soil types of Hungary (meadow and forst soils) is caused by the different ratio of manganese to molybdenum in the two soils. While the meadow soils have a good molybdenum- and poor manganese-supplying capacity, in forest soils the concentration of mobile manganese is high and the availability of molybdenum low. Accordingly, the meadow soils provide a natural habitat for molybdenophilous, and the forest soils for manganophilous plants. The ratio of the two elements shows the difference in nutrient-supplying capacity between the two soil types more distinctly. In earlier agricultural practice the growing site was made suitable for alfalfa production by applying lime to transitional and forest soils. Today we know that this intervention not only increased the chemical reaction but also improved the availability of molybdenum and reduced that of manganese. I started large-scale experiments based purely on microelement supply on acid forest soils at the foot of the Mátra (range of hills in Northern Hungary) and found that on all soils where the manganese-molybdenum ratio of alfalfa was higher than 100, the crop responded to the application of 2–6 kg/ha ammonium molybdate with an increase in the yield and protein concentration. With the help of this diagnostic limit value alfalfa can be successfully grown on any soil where earlier it could only be produced with a high rate of nitrogen fertilization.

Vinca minor, a plant containing vincamine alkaloids which have a reducing effect on blood pressure, has just the opposite demand for its growing site. Its original habitat is the soil of hornbeam and oak woods. Since at one time the active agent could be profitably exported, Vinca minor was taken under field cultivation at the cost of considerable investments. Under such conditions, however, the virulence of the plant declined, the stands were overgrown by weeds, and fungal diseases also rendered further attempts unprofitable. In the meantime I was charged with the task of examining the microelement implications of the problem. The analysis of samples collected all over the country revealed that the large continuous natural stands of the plant are found in places where the manganese content of the plant is high. By applying ammonium sulphate, which has an acidifying effect, to mobilize the manganese content of the soil, together with manganese micronutrient it proved possible to increase the production of the stands. It should be added that in most cases manganophily is coupled with acidophily. Emphasis was earlier laid only upon the different demands of the plant species for chemical reaction, and the microelement requirements concealed by these were not taken into consideration.

Besides the above many observations prove that differences in growing site cannot be counterbalanced by NPK application alone. Though the mechanical properties, humus content and water regime of the soil cannot be changed, at least not in a short time, differences in the natural fertility of soils can nevertheless be lessened by means of rational microelement application.

The increased frequency of microelement deficiencies is related with the fact that assimilation is enhanced by the better NKP and water supply. In this case the microelements which are relatively less readily available are reduced to a minimum and limit the yield. From the observations made by my colleagues and I three series of measurements are presented here to prove that the replacement of microelements cannot be neglected any longer.

The effect of irrigation was studied for three years with oats as the indicator plant, on four soil types with four fertilization combinations. It was found that for each element the increased (optimum) water supply played a role in decreasing the concentration of mineral substances, including that of the microelements. The decrease in copper concentration, which always followed the yield increase proportionately, was particularly noticeable. For most elements the decrease reached the lower limit of the values recommended from an agrochemical point of view, and as regards the feeding value it was far below the standard. These concentration minima are not affected by the fact that with a larger yield somewhat larger quantities of microelements are removed from the soil.

The natural fertility of a total of 45 soils was examined for three years with maize as the indicator plant. The concentration of most minerals in the dry matter of maize was found to decrease with an increase in the yield. Most of the correlations calculated between the yield and the yield components (23 of a total of 29) were negative and significant. At sites favourable for organic matter production smaller quantities of mineral substances were required for the production of a unit amount of dry matter. This fact is favourable to a certain extent, at least from the point of view of crop production, since in that case the amount of nutrient extraction (nutrient replacement) to be reckoned with is smaller. On the other hand, an analysis of the components of the plants on these naturally fertile soils shows that if the microelements are reduced to a minimum they limit the development of still larger yields. The fact that the microelement content decreases with the increase in yield means that the user, e.g. the livestock farmer who feeds fodder, is uncertain as to the value of the components in the rations. Material balance disturbances of alimentary origin occurring in cattle breeding are due in large part to large yields deficient in microelements. The solution lies, naturally, in soil conservation, taking the meso- and microelements into consideration, rather than in returning to the extensive system of farming.

The above statements hold true under field conditions as well. In national long-term fertilization trials the maize crops obtained for two years from four treatments at four growing sites were analysed. At Keszthely, when the data of 24 plots were taken into consideration, a correlation expressed by the equation Zn ppm $= 25.7 - 0.099$ q/ha was found between the zinc content of maize leaves and the amount of yield. In the same series of measurements at Mosonmagyaróvár, the molybdenum content was found to decrease with an increase in yield; this correlation can be described with the equation Mo ppm $= 2.77 - 0.916$ q/ha. These correlations definitely do not mean that the larger yield is "caused" by the lower microelement concentration, because if the limiting elements are supplied a further increase in the yield is observed.

Temporary and rational solutions exist for the elimination of the gradually increasing microelement deficiency. As long as no satisfactory diagnostic procedures applicable to regions and plant species are available, the use of multi-component microelement fertilizers is acceptable. These are mixtures of macro-, meso- and microelement salts which are able to make up for a smaller extent of deficiency when applied through the leaf. For small producers who grow a variety of plant species on a small area this solution may be rational and economical for a long time to come, as the costs of diagnosis would not be refunded. In large farms, on the other hand, it is neither rational nor economical for the burden of a range of other elements besides the missing copper, for example, to be laid on the plant, the environment and the financial capacities of the farm. It is a serious mistake to think that seemingly small amounts (surpluses) of these go unnoticed by any member of the nutrition chain. In addition, it is to be feared that these mixtures, like the mineral and vitamin premixes used in livestock farming, will be used for a misconceived prevention. One consequence of this practice, though not perhaps the most serious is an increase in the production costs.

In rational, economical microelement nutrition, which also protects the environment, only the yield-limiting or component-limiting microelements are supplied, together with a very slight safety surplus. The fulfilment of the above conditions is made possible by a knowledge of both the properties of soil and the requirements of the plant.

The microelement levels of the soil types in Hungary are fairly well known. While studying the natural vegetation of acid and calcareous sandy soils, alluvial soils, meadow soils, marshy soils, alkali soils, lithomorphous and brown forest soils and chernozem soils, my colleagues and I were able to generalize several characteristic features. For example, chernozems, calcareous alluviums, calcareous sandy soils, rendzines and the soils of the Hungarian fens have a low manganese-supplying capacity. In sandy and fen soils the copper levels are low. The podzolic and brown forest soils have a poor moybdenum-supplying capacity. In the upper layers of some alkali soils and those in the process of alkalization boron may accumulate in dangerous amounts. Nobody claims (not even the trade propaganda) that the same mixture should be applied to all these soils. Yet, for lack of a better solution or of exact diagnoses, for the sake of convenience or due to subjective evaluations (e.g. the crop has turned green) superficial solutions are for the time being the most frequent.

In judging the relationship between microelement and plant it has not been realized sufficiently that the microelement uptake is phylogenetically determined, is highly characteristic and varies with the taxon. The family to which a plant belongs can be determined with a high degree of probability just from the ash of the plant. On the other hand, the microelement composition and requirement of a plant species can be predicted to a good degree of approximation from its taxonomic place. While studying nearly two thousand species I found a high copper content, for example, in the Solanaceae, a high zinc content in the Salicaceae, a low copper content in the Abietaceae, a high molybdenum content in the Resedaceae and Fabaceae and a low boron content in the Gramineae. Thus the copper demand of sunflower compared to that of maize, or the boron demand of alfalfa compared to that of the grasses, for example, are higher by an order of magnitude. The manganese content of hornbeam and oak is two orders of magnitude higher than the manganese level of Acacia, etc. In possession of such knowledge it is very risky to recommend universal preparations. By studying 54 plant families, all natives of Europe, I have demonstrated that the variation coefficients of the mineral contents in the different taxons are much higher for the micro- than for the macroelements. This observation also confirms that in making up for microelement deficiencies a distinction must be made between the plants.

The detection and termination of microelement deficient conditions are made increasingly urgent by the present scarcity of material and energy. By applying exact scientific methods the energy of the sun — the only cheap source of energy — could be better utilized, thereby alleviating our food problems.

TULCZ, I.: I think that the increasing importance of the microelements cannot be the subject of controvery, particularly as farmyard manure can no longer replace microelements in the quantities in which they are extracted from the soil by the higher yields. In my opinion examinations carried out using leaf analysis are highly important. The laboratory network now under construction will have the important task of giving sufficient information to the producers on these questions.

The helicopters now widely used for plant protection purposes make it possible to replace trace elements through the leaf during the growth season.

Fertilizer production in Hungary should develop in this direction; the most frequent microelement deficiencies should be made up for by adding the necessary microelements to the fertilizers.

*

PÁL, GY.: **If fertilizers are to be used according to nutrient needs, cultivated plants should be supplied during the growth season with those kinds and amounts of nutrient which they require in order to produce the expected yield. On this basis, do you consider that the quality of the fertilizers now available in Hungary is acceptable, and are the farms justified in making no distinction between the fertilizers according to active agent content, chemical action and long-range effect?**

ÁCS, A.: I agree that the incorrect chemical composition and method of application of the theoretically determined amount of nutrients cause losses to the national economy amounting to several million forints. In this respect there is too much carelessness and lack of proper planning.

I think that while the quality of Hungarian fertilizers is good, they are not properly utilized. One reason is the insufficient choice of commercially available fertilizers, so that they cannot satisfy special demands. Further difficulties concerning the efficiency of fertilization arise from the fact that the special conditions under which the nutritive substances fixed in the fertilizer become available to plants are not taken into consideration. To give an extreme example: in rice cultivation ammonium sulphate is an efficient fertilizer, while nitrogen applied in the form of nitrate remains ineffective.

The active substance of phosphorus fertilizers can be bound in different ways. It depends on the type of soil, and on its chemical and physical properties, how these active substances are bound, thus becoming unavailable to the plant. In this respect the experts from the Agrochemical Stations could be of great assistance.

The large-scale mixing of fertilizers before application still leaves much to be desired. Similar objections can be raised against the way in which the fertilizers are spread. The high capacity fertilizer distributors used on large farms do not ensure uniform application. And this is crucial for efficient fertilization. The elimination of this deficiency should be the aim of technical development. High output and even distribution!

BARACS, J.: As far as we know, the Hungarian-made mono-fertilizers currently available do not always reach the quality required for the up-to-date machines. The only exceptions are the 34% ammonitrate produced by the Tisza Chemical Combinate, and the carbamide made at Pét. The farms should distinguish between the fertilizers according to active agent content, chemical action and duration of activity. This is why the demand for granular superphosphate, and particularly for simple superphosphate is decreasing, while that for triple-phosphate shows a rising tendecy. Another problem is that none of the currently available nitrogen fertilizers has a sufficiently long-term action. The dry fertilizers manufactured at the Peremarton Chemical Enterprise (Peremarton) and the Tisza Chemical Works (Szolnok), as well as the mixed fertilizers produced by means of cold granulation at the same factories do not meet the quality requirements (uniform size of grain, resistance to crumbling, correct composition of active agents) of the farms either. It should also be mentioned that calcium should be listed among the fertilizers and given all the price preferences enjoyed by the fertilizers. The gradual acidification of the soils means that liming is badly needed.

BAYER, F.: The unskilled use of state subsidized fertilizers represents a great wastage. It is unpardonable to apply fertilizers without distinction as to the active agent content, chemical (e.g. acidifying) action or long-term effect. So it is a very good thing that specialists from the Plant Protection and Agrochemical Centre of the Ministry of Agriculture and Food are now working on the propagation of correct fertilization techniques all over the country.

BEKE, F.: The new system of soil analysis will no doubt give an answer to this question within a few years. If the nutrient supply is to be economical on various types of soils, simple fertilizers will also be needed. Efficiency is an important factor in quantitative crop production.

BEKE, I.: The quality of the Hungarian fertilizers available at present leaves much to be desired, but even these fertilizers are not produced in sufficient quantities and there are also marketing problems.

The practice whereby no distinction is made between the fertilizers as regards active agent content, chemical action and long-term effect is out-dated and untenable in the long run.

This incorrent practice can be traced back to

— a relatively limited range of fertilizers,
— the absence of relevant literature, and
— a shortage of professionals trained for this special purpose.

A more realistic and economic system of fertilization requires stricter technological discipline and a more rational use of fertilizers on the farms. In addition, a fertilization programme based on soil analyses, an adequate range and amount of fertilizers, and the necessary technical conditions for fertilizer storage and distribution are also indispensable.

BUZÁS, I.: When fertilizers are supplied according to the nutrient requirements of the crop a sharp distinction should be made between the concept of nutrient demand (requirement) and that of fertilizer demand (requirement).

By nutrient demand we mean the amount of nutrient taken up and used by the plant for the production of the planned yield. The amount of fertilizer to be applied is different. The quantity of nutrients present in the soil, the nutrient-fixing capacity of the soil, and possible losses must also be taken into consideration. The fertilizer demand may thus be either higher or lower than the nutrient demand; it is, in fact, the amount of nutrient by which the nutrient requirement of the plant can be met under the given conditions.

Accordingly, nutrients should not be applied in the proportions demanded by the plant; the nutrient composition of the fertilizer should be determined so as to develop a ratio of available nutrients in the soil suited to the nutrient requirements of the plant.

If by "fertilizer application according to the nutrient requirement" the above is meant, it is indispensable to make a distinction between the fertilizers as to active agent content, chemical action and long-term effect. It is not, however, in the farm that differentiation must start; the long-range development plans of the fertilizer industry and trade must be made accordingly.

The fertilizer trade must not be allowed to satisfy only the active agent demand of the farm, but to refuse to supply fertilizers in the combinations ordered.

The expert advice given to the farms on fertilization should include proposals for the type of fertilizer to be used under the local conditions, after a study of each field separately.

For the last two years important measures have been taken in all three spheres mentioned above. An outstanding role in shaping the long-range development plans has been given to the Plant Protection and Agrochemical Centre of the Ministry of Food and Agriculture, which right from the beginning has urged the fertilizer trade to satisfy the demands with a wide range of fertilizers of an adequate quality. In this way they wished to serve the interests of the farmers.

At present the Plant Protection and Agrochemical Centre, with the assistance of the best theoretical and practical experts in the country, is working on the improvement and standardization of the fertilization advisory service.

DEBRECZENI, B.: At the present average level of fertilizer consumption in Hungary 300 kg/ha NPK, around 1.5 million tons of NPK active ingredient, are used each year. Apart from supplying the plants with nutrients this large quantity of chemical substances may induce many harmful chemical processes in the soil and environment. It is therefore extremely important to have exact knowledge of the chemical composition and physico-mechanical properties (quality) of the fertilizers. The quality of the Hungarian-made simple and complex solid fertilizers currently used is often below standard. The raising of these standards and the strict control of quality are important tasks. It follows that closer co-operation is required between manufacturers and users with a view to a realistic determination of the quantitative and qualitative requirements and criteria.

The quality of the fertilizer decisively influences the whole process of utilization: transportation, storage, mixing, ways and means of distribution, conversion and efficiency of fertilizers. Most fertilizers have, either directly or indirectly, a greater or lesser acidifying effect on the soil, as a result of the free acid content, or of the physiological, biological and so-called adsorption and leaching acidity. The right quality of fertilizer must therefore be chosen and applied, taking the type and chemical reaction of the soil into consideration. To avoid the further acidification of acid soils it is expedient to lime, or to use the lime index for nitrogen fertilizers. Of all the physico-mechanical properties of the fertilizers it is particularly important to know the value of the so-called critical relative humidty (CRH), that is, the point at which the substances deliquesce, in order to be able to store and mix the fertilizers properly.

Hungarian farmers are generally familiar with the major nutritive elements of the fertilizer active ingredients, and take them into consideration, since without this the necessary amount of fertilizer cannot be determined. Less attention is paid, however, to the form and solubility of the active agent compounds, and thus to the processes by which they are transformed in the soil. Apart from the major active ingredients many simple fertilizers also contain a range of secondary nutritive elements (Ca, Mg, SO_4) and dispensable subsidiary elements (Cl, Na, Si, etc.). The long-term effect of fertilization, that is, the after-effect, which may last several years is not usually reckoned with, but in the integrated national advisory service on fertilization which is to be set up, due attention should be paid to this important factor.

HARASZTI, E.: In order to use the fertilizers according to the nutrient requirements of the plants a distinction must be made between the fertilizers as to their effective substance content, chemical action and long-term effect. In general, the more the user knows about the nutrient demand of the cultivated plant and the properties of the fertilizer available, the better he can use them as a "strategic weapon" in order to attain large yields.

HARMATI, I.: The quality and composition of the current Hungarian fertilizers does not meet the requirements of up-to-date fertilization in several respects:

1) Owing to the uneven grain size and the frequent stickiness of mono- and complex fertilizers, uniform distribution cannot be attained.

2) The quantitative ratio of mono- to complex fertilizers is poor. Much larger amounts of complex fertilizer are needed (at reasonable prices) to eliminate unsatisfactory mixing and to promite the uniform distribution of fertilizers.

3) The assortment of complex fertilizers is not sufficiently wide. Complex fertilizers should be produced in which the ratio of active ingredients is adapted to the nutrient demands of the major crops, taking the NPK levels of the soils into consideration. Besides the macroelements certain microelements should also perhaps be included.

4) Nitrogen fertilizers containing $CaCO_3$ and $MgCO_3$ are scarce in Hungary, though these are particularly necessary for acid soils (2.5 million ha). Ammonium nitrate and carbamide further increase the acidity of the soil, so they are much less efficient than calcareous fertilizers.

The elimination of these deficiencies would be a big step forward.

Something must also be done about the fact that a considerable proportion of the farms do not take proper care to see that the types, amounts and ratios of the fertilizers used are adapted to the conditions of the farm and to the crop in question. This is partly due to the fact that they are not sufficiently familiar with the nutrient demands of the plants and the soluble NPK contents of their soils, or with the types of commercially available fertilizers and their physiological effects. On the other hand, they cannot always buy what they would like to, when they need to. With the extension and improvement of the advisory service some of these problems will be solved.

In addition, closer co-ordination of the interests of the manufacturing industry, traders and users is indispensable.

HELMECZI, B.: The experimental methods used to determine the nutrient contents of soils and the nutrient requirements of plants, and the results of small plot field experiments are not yet reliable enough to justify the objections raised against the practice of using fertilizers uniformly, irrespective of their quality. At present the errors originating from a uniform application of fertilizers are hardly likely to be greater than those caused by the deficiency of the methods of determining the fertilizer doses. The experimental methods must be improved and the calculations made more accurate before the farms can be obliged to make a distinction between the fertilizers on the basis of quality and composition.

HUSTI, M.: Fertilizers should be used so as to satisfy the nutrient requirements of crops during the vegetation period. Since fertilization cannot always be carried out during the vegetation period, both slow- and quick-acting fertilizers should be applied. The chemical reaction of the soil in different agricultural areas varies, so fertilizers with different chemical reactions are needed. Most of the commercially available fertilizers do not meet the requirements of uniform distribution and satisfactory storage. At the present level of technology pulverized fertilizers cannot be evenly distributed. A large number of granulated fertilizers can only be used after grinding. This involves extra costs for the farm, and even so the material obtained will not be homogeneous. According to our present knowledge uniform nutrient distribution cannot be achieved with such fertilizers. Even when the greatest care is taken there is a $20-30\%$ margin of error. This is inadmissible when the nutrient management is based on soil and leaf analyses.

KEMENESY, E.: The most difficult problem involved in supplying various kinds of fertilizer (NPK) lies in determining the rate and manner of distribution of nitrogen fertilization. Phosphorus and potassium fertilizers are hardly leached at all, and laboratory analyses give some information as to the rate which should be applied. Moreover, by giving an overdose of P and K the nutrient level of the soil can be increased. Nitrogen fertilizers, however, are exposed to the danger of leaching, and when they are supplied in overlarge quantities they may cause a yield depression.

For methodological reasons the problems involved can be elucidated by taking two plants with different demands as examples.

1) Wheat and nitrogen.

Wheat is the crop which reacts most sensitively to nitrogen fertilization, because there is less time between the removal of the pre-crop and the sowing of wheat for the decomposition of root residues of various sizes and qualities (C—N ratio).

Nineteen years ago at the experimental station of the Keszthely institute (brown forest soil formed on loess, pH 6.9, annual precipitation 720 mm, mean annual temperature 9.8°C) pre-crop experiments were carried out on two occasions with 24 pre-crops and threee main crops. Table 1 only shows the effect of various pre-crops on wheat. It was found that these could be arranged in a certain order. At the same time, for methodological reasons no organic or artificial fertilizers were used, and the winter wheat was sown on the same date after all the pre-crops. This was done in order to make the so-called theoretical pre-crop value of the cultivated crop as clearly visible as possible. It was interesting to see the range of colours from yellowish green to fierce green caused by the different pre-crops, which reflected the extent of the nitrogen supply. It was found that while winter wheat showed an average of 37% yield fluctuation as a response to the 24 pre-crops, with spring crops, notably in spring barley, thus difference was only 16%, and in a combination of grass and clover it was as low as 7%. This can be explained by the fact that while in the case of wheat, as an autumn-sown crop, the nitrogen is tied up in the decomposition of the plant residues of the different pre-crops, with the spring crops these processes are nearing completion (sowing on 2nd April). A further reason is that the differences in the extent to which the pre-crops dry out the soil more or less disappear by the time spring crops are sown, owing to autumn ploughing and the subsequent winter precipitation. In the combination of grass and clover the effects of pre-crops were even less perceptible than in the case of spring barley, because one of the partner crops was clover which is known to be less sensitive to occasional nitrogen deficiencies.

Our results were confirmed by L. Kreybig's statement to the effect that the more fertile the soil, and in particular the higher its N-supplying capacity is, the smaller the differences in the after-effects between good and bad pre-crops will be, because a soil rich in nitrogen is less affected by the nitrogen fixation occurring during the disintegration of roots of unfavourable composition.

The yield difference between the two extremely coloured wheats (yellowish green and fierce green) was 396 kg/ha. If the effects of the different sowing times and ripening possibilities had also been taken into account, these differences would have been still greater. This suggests that sharp distinctions should be made in the amount of nitrogen supplied to various crops.

a) Optimum rate and distribution of nitrogen fertilization. Farmers are interested in obtaining as large a yield as possible. At sufficiently high phosphorus and potassium levels this can be achieved most efficiently by applying an optimum rate of nitrogen fertilization. To this end a great number of negative and positive factors must be taken into account, which after due consideration may give some hint of how to approach the optimum rate of nitrogen. application. An overdose of nitrogen increases the danger of lodging, and makes the plants more susceptible to pathogens. There is also a risk involved in the unknown weather conditions.

Breeders are faced with the problem of developing varieties with greater standability and increased resistance to pathogens, which also satisfy other requirements. This task is by no means easy, because in the majority of cases opposing correlations must be overcome.

b) Agrotechnics and nitrogen rates. In determining the amount of nitrogen to be supplied the following agrotechnical aspects must also be taken into consideration:

- the quality of the soil preparation, by means of which the degree of nitrification can be increased. In addition, soil free of lumps also reduces the danger of lodging;
- the optimum rate of nitrogen fertilization also depends on the date of sowing. Delayed sowing can be corrected somewhat by supplying an extra dose of nitrogen early in spring;

Table 1

Relative pre-crop effects with winter wheat as main crop Keszthely (two-year average)

1. Legumes	
vetch	112
lentil	106
sand pea	103
pea (Express)	100
dwarf bean	94
soybean	78
average without soybean	103
2. Early pre-crops	
rape	98
mustard	98
mixture of oat and vetch	96
oil flax	90
poppy	90
average	94.6
3. Late pre-crops	
maize sown thickly for fodder	88
hemp	86
sunflower for silage	84
maize for silage	82
Sudan grass	79
average	83.8
4. Cereals	
rye	86
oat	85
winter barley	83
winter wheat	80
spring barley	79
average	82.6
5. Row crops	
early potato	91
late potato	85
early maize	85
average	87

— the previous application of organic manure (including alfalfa and clover), which may improve the porosity of the soil and develop a better soil structure, thus making the water regime more favourable;
— the early removal of pre-crops renders a maturing soil cultivation possible. The stubble fields of leguminous crops contain a surplus of nitrogen (30—50 kg/ha) with the additional advantage that the nitrogen is not supplied suddenly as in the case of fertilizers, but continuously, though in small quantities, almost up to the end of the growth season, according to the requirements of the wheat. This is perhaps why peas have a particularly good yield-increasing and quality-improving effect as pre-crops, even if this is augmented with N-fertilization.

c) When should nitrogen be supplied and on how many occasions? The nitrogen demand of wheat varies according to the phenophase, and is highest in the last phase, from shooting to grain ripening. In the developed countries nitrogen is supplied on two, or sometimes three occasions: immediately after sowing or during the winter frosts, then at tillering, and finally at the beginning of shooting. Experimental results show that divided nitrogen fertilization not only results in yield surpluses (2—3 q/ha) but may also lessen the danger of lodging and increase to some extent the gluten content of the wheat. To follow this method in its entirety might not be advisable in Hungary because of the frequent dry periods and heavy soils. On the other hand, additional nitrogen application to poorly developing wheats is best carried out during tillering. It should also be emphasized that, besides the objective factors that influence the nitrogen fertilization of wheat, observations made by experts are also important, as the determination of the minimum N content of the soil continually changes, depending on the weather.

d) Alfalfa as a pre-crop for wheat. A continuous N supply to wheat can best be solved with alfalfa as the pre-crop. There are, however, certin conditions to this, namely, the last curring, which is usually the smallerst anyway, must be omitted, and the alfalfa field must not, of course, be overgrown by weeds. The alfalfa must be ploughed out early if the soils are to be properly prepared. In this case the nitrogen contained in the organic residues of alfalfa will be equal to that found in fairly good quality farmyard manure. The emphasis should be laid on a continuous supply of nitrogen up to the end of the wheat vegetation period.

Ploughing out should be carried out in August with a shallow plough adjusted to a working width as large as possible so that the green part of the slice cut off will fall to the bottom of the furrow. The field thus stripped is immediately worked over with a ring-roller attached to the plough, so as to make the decomposition of organic residues as efficient as possible. This process of decomposition takes place not only in the slice of soil cut off, but also in the root remnants left in the subsoil, since they are also dead. After several weeks of decomposition the soil should be worked with a disc, or some other suitable adapter, crosswise to the direction of ploughing, in order to break the decayed matter into small pieces, and then with a roller to assist the decomposition further. After a few weeks the organic mulch thus developed is given a combined ploughing and rolling. Soil treated in this manner is perfectly mature (naturally, sufficient phosphorus and potassium fertilizer to last for several years must be distributed before ploughing). This method of ploughing may require more work, but it is still economical because of its outstanding effectiveness. This method was already being used in the thirties. In experiments carried out in 1951 at Keszthely the yield was characterized by the following relative figures:

after ploughing down once in late autumn	100
after maturing soil preparation	122

Mention should also be made of the importance of slow action N-fertilizers. Owing to their slow action these fertilizers maintain their nitrogen-supplying capacity throughout the growth season. They are carbamide-aldehyde condensates put on the market under various names (Ureaform, Nitroform, Formurin, etc.). They are of special importance on light soils in crops with a nitrogen demand which is highest in the generative phase (wheat, maize).

Finally, if the optimun nitrogen demand of wheat had to be determined numerically it would not be a great mistake to say that it ranges from 80 to 180 kg/ha active agent depending on the local conditions, the standability of the variety, the pre-crop, the agrotechnical level and the sowing date. In other words, great care must be taken in determining the dose of N fertilizer.

2) Nitrogen fertilization of alfalfa.

Opinions differ greatly both in Hungary and abroad with regard to the nitrogen fertilization of alfalfa. Agriculturists very often draw general conclusions from their local experiences and experimental results. The following directives may help to settle the question of the nitrogen supply to alfalfa:

Alfalfa, like most papilionaceous crops, has a high nitrogen requirement, perhaps the highest of all the papilionaceous plants, probably because it produces the largest quantity of protein per unit area.

Alfalfa covers its nitrogen requirements from two sources:

a) through the nitrogen-supplying capacity of the soil, and

b) self-sufficiently, through the activity of rhizobia.

On not excessively heavy soils rich in nitrogen (humus) where the conditions are favourable for the activity of rhizobia and for nodule formation, alfalfa does not require nitrogen fertilization, as it is able to cover its nitrogen requirements fully from the two sources mentioned above. This does not, of course, mean that alfalfa would not respond to nitrogen fertilization even under such favourable conditions. Due to its nitrogen hunger it immediately absorbs the offered nutrient, at the expense, however, of reducing its nitrogen-collecting activity, i.e. the free N production. This suggests that under such favourable conditions there is no sense in supplying nitrogen even if this produces a slight effect, because this means that the highly useful, free rhizobium activity will not be exploited. The available nitrogen fertilizer supplies would be better used for non-papilionaceous crops. Thus, within the farm the nitrogen fertilizers must be used where they will be the most productive from the point of view of the total output of the farm. Of course, if cheap nitrogen fertilizers were available in abundance it would be easier to dispense with the assistance of the rhizobia. In some regions of the United States, for example, nitrogen fertilizers are regularly supplied to alfalfa even where, according to our more classical views, it is not justified.

In many cases, of course, the nitrogen fertilization of alfalfa may be both justified and economical. These are:

- when the nitrogen-supplying capacity of the soil is low, such as in the light-coloured soils with low humus contents, and in those which are poorly supplied with organic matter owing to the low animal density;
- when the soil is too heavy and packed (e.g. meadow clay, alkali soils, heavy forest soils), where, for lack of sufficient air, the activity of the rhizobia and the formation of root nodules is not satisfactory. The extent of nodule formation can be assessed by establishing the density of nodules after carefully lifting the roots with a space from the previously irrigated soil;
- under irrigated conditions, when the N-supplying capacity of the soil and the N-collecting ability of the plant cannot, even together, cover the full nitrogen requirement of the large yield thus obtained. Such cases occur, for example, on irrigated sandy soils poor in humus (low N-supplying capacity) and on over-heavy, irrigated meadow clay soils (deficient nodule formation due to lack of air).
- Nitrogen fertilization may be justified in old alfalfa fields where the N collection has usually declined.

The cases listed above are only directives as to when the nitrogen be wasted, and when it is not advisable to economize on nitrogen. The actual solution should be decided on the basis of simple field trials. It is only after these have been completed that a decision can be made as to whether it is worth applying nitrogen fertilization to alfalfa, and if so, at what rate. This must be known partly in order to maintain the free N-collection, and partly to be able to approach the optimum rate of nitrogen application under given conditions. In an experiment carried out at Keszthely an attempt was made to settle this question by supplying 0, 50 and 200 kg/ha nitrogen active agent at a proportionate level of phosphorus and potassium fertilization. Even these extreme rates of nitrogen fertilization did not produce significant differences. The differences in the total hay yields for the 3 years can be expressed by the following relative figures:

N ∅	N 50 kg/ha	N 200 kg/ha
100.0	102.7	102.9

To clarify the question pot experiments were also carried out and it was found that if nitrogen was supplied beyond a certain level it resulted in the total disappearance of the rhizobia.

Kiss, A. S.: Nutrient replacement should be adjusted according to the crop and the expected yield on the basis of soil analysis. Since the nutrient demand of the plant depends not only on the species but on the variety too, proper fertilization (adjusted to soil and crop) can, in my opinion, only be achieved with individual fertilizers, or by making up complex fertilizers from individual fertilizers in the right proportion. Thus, no complex (NPK) fertilizer can be universally good, and we cannot even speak of wheat or maize fertilizers, etc. Today it sounds exaggerated to speak of the nutrient demand of a particular variety of wheat or maize; nevertheless, according to our investigations the nutrient demand really ought to be broken down to this level. This is connected with the ionophylous nature of plants, as pointed out in an earlier publication of ours.

According to our investigations the efficiency of fertilization is a function of the sowing time, among other things. Plants growing from seeds sown at the proper time utilize fertilizers better, while those sown earlier or later require a larger volume of fertilizer to attain the same yield level.

If, for example, the different acidifying and long-range effects of nitrogen fertilizers are considered it is inadmissible that no distinction is made between them as regards the long-range effect of their active agent contents and the extent to which they can be mixed. It might be well worth offering extension training in nutrient replacement to professional agriculturists.

Kiss, Á.: If fertilization is to be carried out according to the nutrient requirement, the Hungarian fertilizers must have reliable active ingredient contents, chemical actions and storability. The quality of the fertilizers should be improved, and the farms should be supplied with fertilizers which satisfy the nutrient demand of the plant during the growth season and ensure the long-term effect.

Koltay, Á.: A considerable proportion of the fertilizers used are in powder form and are delivered to the farm in bulk. Such fertilizers become lumpy after a time, and can only be uniformly distributed after an expensive preparation process.

An up-to-date nutrient supply involves the simultaneous application of NPK and other necessary elements. The successive application of fertilizers with a single active ingredient, or mixing them immediately before distribution, often leaves much to be desired. It is often impossible to provide the conditions needed for mixing if the required homogeneity (grain size, identical specific weight, etc.) is to be obtained. Consequently, the use of complex fertilizers mixed in the factory will be of great importance until the conditions for perfect fertilizer preparation within the farm are established, with properly mechanized fertilizer stores. The granulated complex fertilizers contain the three main nutritive elements at a higher concentration, and may also contain the major microelements. Granulated fertilizer is free of dust, does not stick together and can be distributed fairly evenly with various kinds of implements. The production and utilization of fertilizers must be further improved in Hungary. A point must be reached where the active agent content, composition and form of the fertilizer produced will accord better with the requirements of the users. The quality and packaging must be improved, and loss-free storage and delivery must be ensured. Inaccurate techniques and uneven distribution also reduce the efficiency of the large amounts of fertilizer used. Utilization must be improved in every respect. Nutrient replacement must be developed into a system based on regular soil and plant analyses.

Kovàts, A.: The more rational and economical the use of fertilizers is to be, the stricter the criteria for the quality of the fertilizer, as regards both its physical and chemical properties (active agent content, chemical action, long-term effect). Some of the current Hungarian fertilizers do not meet these requirements, mainly because of their physical properties (grain size, coagulation, etc.). The Hungarian fertilizer factories cannot be blamed exclusively for this, as the available equipment only allows a certain production technology to be used. The aim of development should be to improve the manufacturing of fertilizer, not only quantitatively but also qualitatively.

Rational fertilization based on the nutrient requirements of the plant and the fertility of the soil should pay increased attention to the type of fertilizer applied. This means that active agent content, chemical action and long-term effect should all be taken into consideration. There may be different requirements with regard to soil type, pH value, etc., and in some cases with regard to the aggregates of the fertilizer (e.g. the chloride content of potassium salts, the biuret content of carbamide).

The nutrient content of the fertilizer determines the amount to be applied, so the farms should pay attention to the composition of the fertilizer they will be using.

This raises the question of complex fertilizers, on which opinions often vary. Although this problem could be solved by widening the range of fertilizers and manufacturing complex fertilizers with different active agent ratios, this nevertheless involves questions of distribution and storage that are difficult to settle. It may well be that with a high rate of fertilization the application of complex fertilizers will be more expensive than the distribution of traditional fertilizers on two occasions. For starter fertilization, however, complex fertilizers are very useful.

LÁNG, G.: The inadequate physical properties of the fertilizers cause the farms many difficulties in the course of application. Regular phosphorus and potassium fertilization compensates to some extent for the disadvantages arising from uneven distribution provided it is not too uneven. Thus pulverized superphosphate can also be used quite efficiently. Damage caused by the unevenness of distribution appears primarily in the case of nitrogen fertilizers. This is why liquid nitrogen fertilizers are of special importance, as their uniform distribution can be ensured even under large-scale conditions.

Great attention should naturally be paid to the active agent content, chemical reaction, etc. of the fertilizers. The agrochemical and plant growing criteria for selection are well documented and generally familiar.

LŐRINCZ, J.: Up-to-date nutrient supply requires up-to-date fertilizer production. Unfortunately, the fertilizer supply in Hungary does not cover the requirements of modern crop production. The quality also needs improving. The farms are quite justified in demanding that they should receive the amount of active agents they have paid for, in a form which does not require any further processing (e.g. grinding). The quality of granulation can, for example, influence the uniformity of distribution, so a demand of this kind by the farms is also justified.

MIHÁLYFALVI, I.: Artificial fertilizer requirements can be correctly determined only by regular nutrient analyses in which the long-range action can be taken into account. In establishing doses and ratios a distinction must definitely be made between the different crops. Nowadays "balance-like" fertilization is an antiquated concept. Justifiable objections are raised currently as to the quality of Hungarian artificial fertilizers, but if nothing better is available these must be used. In the future greater attention should be paid to the production and distribution of combined artificial fertilizers.

MOLNÁR, J.: The quality and availability of fertilizers is not always satisfactory in Hungary. The faults which occur most frequently are:

— deficiency of active agent due to inaccurate manufacturing techniques, unsatisfactory granulation, the lumpiness of the fertilizer;
— lack of choice, particularly of complex fertilizers;
— inadequate packaging;
— unpunctual delivery.

Out-of-dateness and incompetence are unpardonable both in industry and agriculture.

NYÉKI, J.: The higher the achievements we aim at, the more differentiation there must be in the co-ordination of the factors influencing the yield. During the last ten years Hungarian agriculture has been able to satisfy the demands of the national economy. The results suggest that further development is possible. Mention should again be made of the need for proportionate development, since the choice of fertilizers required to achieve a 30—40 q/ha yield level is not suitable for making further progress.

Development should come about in two directions:

1) The range of fertilizers should be widened so as to ensure the availability of a fertilizer composition optimum for the given procedure and soil conditions at the required time.

2) Manufacturing should be improved so that fertilizers are available in the form best suited to the user.

In the first case mention should be made, for example, of the unfavourable influence exerted by NH_4NO_3 fertilizers containing 34% nitrogen on the chemical properties of some soils, or to the need for sufficient amounts of superphosphate to be available in time for top dressing.

In the second case I am thinking of adhesion, and of fertilizers with different particle sizes and specific weights, which when mixed cannot be uniformly distributed over the area.

With a view to progress I consider that liquid fertilizers should be introduced as soon as possible, because they enable the above-mentioned difficulties to be overcome provided the necessary technical conditions exist.

Pais, I.: The range of fertilizers produced in Hungary leaves much to be desired, but the responsibility for this does not lie primarily with the chemical industry. Fertilization according to nutrient requirements is still only a scientific desire rather than the practice on most farms. The farms must soon arrive at the point where they differentiate between fertilizers according to active agent content, chemical action and long-range effect.

Pecznik, J.: Although the choice of Hungarian fertilizers has widened in recent years it is still fairly restricted. Apart from small quantities of ammonium sulphate and calcium nitrate, nitrogen fertilizers are only available in practice in two forms: ammonium nitrate and carbamide. There is virtually only a single type of phosphorus fertilizer: superphosphate. Potassium is mostly supplied to the plants in the form of potassium chloride. The proportion made up by complex fertilizers is not significant. Many objections can be raised against the quality of nitrogen and phosphorus fertilizers, which are sold in large quantities: those containing ammonium nitrate are hygroscopic, so after long periods of storage they coagulate; the pulverized superphosphate not only contains very little active agent, but it also becomes lumpy and difficult to spread. This causes many problems for the farmers, but just to reduce the hygroscopy of the ammonium nitrate fertilizer would involve an investment to the order of a thousand million forints.

It is naturally unpardonable for any farm to ignore the active agent concentration of the individual fertilizers, since there may be considerable differences between them in this regard (carbamide 46% N, ammonium nitrate 34% N, calcium ammonium nitrate 25—28% N, etc.). However, since no slow-action fertilizers are available in Hungary, no difference in long-term effect can be found between the fertilizers. For various reasons not detailed here it can nevertheless be stated that for top dressing, nitrate-containing fertilizers should be used wherever possible; it is advisable to plough carbamide into the soil immediately after distribution. The use of calcium ammonium nitrate (Pétisó, Agronit) may be justified, particularly on acid soils.

Petrasovits, I.: It is inadmissable for farms not to make a distinction between fertilizers according to active agent content, chemical action and long-range effect.

Pozsár, B.: The NPK ratio should definitely be determined according to the nutrient requirements of the cultivated plants. The greatest problem is generally the fact that the NPK levels in the soil are often left out of consideration and the fertilizers are supplied according to the planned yield. It is up to the Agrochemical Service to put an end to this practice, as will no doubt be done in the near future.

Semjén, I.: In order to attain larger yields of better quality, the quality, composition and choice of fertilizers must be improved, even if we cannot hope to reach the level of supply in some countries, where almost every crop has its own specially composed fertilizer.

In the case of the major crops it would be highly desirable to manufacture fertilizers meeting their special demands. Some progress has recently been made in this field, but the choice is very poor, and the composition is not always satisfactory either. Apart from the physical properties the greatest problem is caused by the fact that the active ingredients, which are not cheap anyway, are about 50% more expensive in the compound and complex fertilizers. This is not too encouraging, and they are only used from sheer necessity. At least they are physically acceptable, as they do not stick together. It is impossible to understand why the simple process of mixing should raise the price of the fertilizer by 50%. In my opinion, this is simply a commercial trick, taking an unfair advantage of the demand. The farms are forced to pay the excessive price for these fertilizers as they can at least be satisfactorily applied with the distributors available at present.

It is not for lack of knowledge that most farms do not make a distinction between fertilizers according to their active agent content, chemical action and long-term effect; in most cases they simply have to be satisfied with, and try to apply in some way or other, what they happen to get. The special composition, choice and physical state of the fertilizers must definitely be improved, otherwise the further development of production will come up against serious obstacles.

The nutrient analysis of soils is beginning to gain ground on the farms, but even if this were perfected, with the present range of fertilizers we should only know what we ought to supply.

The conclusion is thus obvious: in order to increase the quantity and improve the quality of production the level of fertilization, particularly the physical state and range of composition of the fertilizers, should be improved urgently. Today, when the other factors of agricultural production (mechanization, plant protection, quality of seed, choice of variety, etc.) are coming ever closer to the desired level, the lack of an up-to-date method of nutrient supply and replacement must not be allowed to obstruct progress.

Shmilliár, M.: In my opinion it is not enough to supply fertilizers according to the nutrient requirements of the expected crop. If fertilizer is applied, presumably it has been found necessary to do so. If only the amount required for the planned yield is given, it will obviously not be enough, as the amount of fertilizer supplied cannot be fully utilized by the plant. Thus the yield potential of the plant cannot be exploited and record yields cannot be achieved. In a favourable case the plant will extract a certain amount from the nutrient supplies in the soil, but the nutrient balance of the soil will not be restored. Therefore more than the necessary amount should be supplied. The farms must take into consideration the chemical action of the large amounts of fertilizers distributed nowadays, and should know how long they take to act. I am unable to give an opinion on the quality of the current fertilizers.

Szabó, B.: Difficulties are encountered with two kinds of monofertilizers:

The 28% calcium ammonium nitrate is granulated, but it becomes cemented in a very short time. The 18% superphosphate, which is also granulated, crumbles and turns to powder very quickly.

Among the complex fertilizers, the one containing boron is theoretically a granulate, but in practice it contains everthing from dust to gravel-size fractions.

It follows from this that though the active agent content of the fertilizers is satisfactory, the fact that they cannot be evenly distributed greatly reduces their value. The efforts now being made by the Hungarian industry to supply unobjectionable granulated and complex fertilizers are welcome, and it is hoped that the present deficiencies will soon be a thing of the past.

As to the optimum ratio of nutrients, fairly accurate data are available for different regions and crops. For this reason the fertilizer industry should be encouraged to produce a variety of complex granulated fertilizers with nutrient compositions adapted to the different crops. I think this would be of advantage in several ways:

- All macroelements required for a crop can be distributed at the same time.
- The nutrients are evenly distributed in the fertilizer.
- Granulates can be better (more evenly) distributed by the existing machines than the traditional fertilizers.

It can be seen from the above that the quality of the present Hungarian fertilizers does not meet the requirements.

Earlier the demand was high and the buyers were less particular. That is why the farms did not always distinguish between the fertilizers according to active agent content, chemical action and long-term effect.

Today these errors are less and less frequent, but they will only be completely eliminated if fertilizer manufacture is improved.

Szalai, Gy.: The quality and reliability of Hungarian fertilizers have improved lately. In consequence of stricter checks the indicated active agent content is, with a few exceptions, present in the fertilizer. Nevertheless, the choice is not yet sufficient. The availability of combined (mixed) fertilizers with different active agent compositions should be improved. Simultaneous efforts should be made to increase the active agent content, mainly in order to reduce transport costs. In fact, today most farms employ specialists who do make a distinction between different types of fertilizer, based on active agent content and long-term effect. The chemical reactions of the various carriers are not sufficiently known at present.

Szalay, S.: Agricultural production is gradually reaching the stage where it requires the same high level of professional knowledge as industrial production does, and demands for organization and work discipline are similarly high. Decisions as to the optimum use of the highly diversified chemicals and fertilizers now on the market need a very thorough professional knowledge. The development of the professional advisory service network will be indispensable. The secondary and higher agricultural education is quite advanced in Hungary. It is to be hoped that as the degree of professional knowledge increases the income of agricultural workers will eventually reach that of industrial employees.

Szeniczey, Cs.: The inexpertness observed in the present use of fertilizers is well known to most specialists. The range of fertilizers available is narrow, and the quality is unalterable. The possibilities of nutrient replacement adapted to the variety and the soil are expected to improved in the near future.

Székessy-Hermann, V.—Fazekas, S.: Choosing the composition of the fertilizer to be applied according to the quality of the soil and the nutrient requirements of the plant is a basic necessity for intensive agricultural production. This fact and the complexity of the problems related to it are shown not only by the large number of articles published on this subject in countries with developed agricultures, but also by the masses of advertisements calling attention to instrumental techniques which are more precise, more rapid and simpler than the earlier ones, and suitable for analysing the composition of the soil.

Tarján, R.: It is inadmissible for farms to apply fertilizers of different compositions without making any distinction between them.

Tulcz, I.: Fertilizers should be produced with a much wider range of composition and active agent content. Hungary's fertilizer industry is not yet capable of putting fertilizers with different active agent contents at the disposal of the farms throughout the year.

One of the difficulties is that neither industry, nor agriculture and trade have the facilities suitable for fertilizer storage. A large proportion of the fertilizers is kept outdoors on the farms, with the consequence that there are considerable losses in value, especially after long periods of exposure to the weather. After being stored in the open for a long time fertilizers may lose up to 90% of their active agent content.

It often occurs at present that farms are obliged to use fertilizers in which one or another component is present in a much larger quantity than is needed, so an unbelievable wastage follows from the fact that fertilizers are not available in the required composition.

*

Pál, Gy.: **The active agent content of the mixed fertilizer distributed today over one hectare of agricultural area in Hungary is approximately 300 kg. There are considerable areas, especially in Transdanubia, which slope to a greater or lesser extent, so that rainwater running off the soil surface may wash the nutrients out of the soil, and some of them may be deposited in standing water. Do you consider the nutrient removal caused by water erosion to be significant in quantity, or dangerous from the point of view of environmental protection, and can you suggest any solution in the field of soil conservation or environmental protection to prevent this?**

Ács, A.: On mountain and hill-side land erosion may occur to an extent depending on the weather conditions, i.e. the amount and intensity of precipitation, in the course of which the fertilized upper soil layer is washed off. Nutrients soluble in water may be washed away even without soil movements, especially when they have not reached the deeper soil layers. These then cause environmental damage by contaminating the water.

This may assume dangerous dimensions. The volume of fertilizer application is continually increasing, often beyond the extent of optimum nutrient supply. The possibility of nutrients being washed away and contaminating the water is thus increasing. This question must be dealt with carefully, as the washing away of fertilizers is the result of the joint action of several factors (volume and water solubility of fertilizers, angle of slope, type and physical and chemical properties of the soil, amount and intensity of precipitation, etc.). The active agent washed away also represents an economic loss, since the plants are unable to utilise it.

The leaching out of nutrients must be prevented if possible by soil conservation, amelioration and environmental protection measures. The volume of fertilizers used on threatened areas must be reduced. Careful techniques of soil cultivation, e.g. contour line cultivation, entrenchment, embankment, can all be hindrances to nutrient leaching.

BARACS, J.: If the fertilizers are properly used the leaching of nutrients on sloping areas is not so great as generally thought. The loss of nutrient arising from soils being washed away by water erosion and deposited in valleys or carried farther away is much greater than the actual leaching of fertilizers. This is naturally influenced considerably by the introduction or omission of farming methods which reduce erosion. Washing away depends on the direction of cultivation, the angle and length of the slope, the intensity of the rainfall, etc.

Measurements were carried out on 46,000 ha in the catchment area of the Baranya canal, where 16,000 ha were covered by forests and 75% of the agriculturally cultivated area was arable; on this area the loss of fertilizer active agents is some 5—6000 tons a year. The soils washed off contain 1—2% humus, and the active agents lost with it cannot be profitably replaced with the present amount of fertilizer, the value of which is not shown in the production results. The yield results on areas with no water erosion (flat lands) were compared with those on areas which slope at various angles. On areas of slope category II the yield of wheat was 83%, and in slope category III only 59% of the yield attained on flat land.

The problem of sloping areas is therefore of great importance from the point of view of environmental protection as well. On these areas complex soil conservation should be started with increased state subsidization in order to raise the level of farming and protect the environment. In Baranya county complex soil conservation has taken place so far on 36,000 ha, and should be extended to a further 100,000 ha soil on the large farms. On these areas the farms are unable to pay for this out of their own resources and thus need to be substantially supported by the state.

BEKE, F.: The danger of leaching does exist, and sometimes assumes serious dimensions, particularly in the case of nitrogen fertilization. It might perhaps be controlled by soil cultivation methods, divided nutrient application, or by ploughing fertilizers into the soil in several layers. However, these methods involve an increase in costs and labour requirements.

BUZÁS, I.: Agriculture, including fertilization and plant protection, cannot be made exclusively responsible for the pollution of waters, e.g. of the standing waters of Transdanubia. It must be emphasized that agricultural wastes, even liquid manures, are not as dangerous as contaminations of industrial and communal origin (industrial and communal wastes, sludge, etc.).

Agriculture, as a combination of crop production and livestock farming, together with the population employed in agriculture, has its place in the cyclic processes of nature, and agriculture itself operates with such processes, e.g. the circulation of nitrogen, oxygen, carbon and water in the process of fertilization-crop production-livestock farming. Ever since ancient times agricultural wastes (manure, plant residues) have formed an integral part of the agricultural production process, being used in agriculture itself.

The major proportion of the wastes produced by industry and the population of cities is not utilized in the industrial processes themselves, nor by the urban population. At the same time these materials are alien to agriculture, being the products of artificially induced processes, and are in fact alien to nature as well (plastics, compounds and concentrates not found in nature, etc.).

On purely agricultural areas environmental pollution does not generally become critical in spite of the increasing volume of material of industrial origin utilized in agriculture. The high concentration of nitrogen, phosphorus and potassium in the standing waters is not due exclusively to NPK fertilization; it is a consequence of overall environmental pollution. Nevertheless, I consider the leaching of nutrients caused by erosion to be considerable for the following reasons:

In the standing waters in Hungary the nitrogen concentration is already so high that from the point of view of the mass reproduction of algae phosphorus not nitrogen is the minimum factor. Phosphorus, on the other hand, is not washed out of the soil, but may be carried into the standing waters on solid particles due to erosion.

I am not sufficiently familiar with the ways and means of preventing erosion to be able to recommend any solution.

GYŐRI, D.: The leaching out of nutrients may be considerable if the farm does not take measures against soil erosion. In general, it is the actual conditions of the farm (angle of slope, exposure, mechanical structure of the soil, etc.) that determine what soil protection measures (contour line ploughing, strip cultivation, banking, terracing, etc.) should be taken. Methods designed to prevent erosion have already been elaborated in Hungary, so they only need to be applied.

HARASZTI, E.: The amount of nutrient washed off the soil by water erosion is considerable and, in my opinion, is dangerous in some regions from the point of view of environmental protection. Leaching may occur not only on sloping areas or in hilly regions, but in any soil with a fundamentally high groundwater level (e.g. in the vicinity of Lake Balaton, etc.).

HUSTI, M.: As I see it, there is a considerable leaching of nutrients caused by water erosion. On areas exposed to erosion the fertilizers must be ploughed in after distribution. Top dressing should only be carried out on such areas when the fixation of nutrients by the soil is ensured. When the surface of the soil is frozen substantial amounts of fertilizer may be carried by the melting snow or rain into standing waters and rivers.

Nutrient losses caused by water erosion are reduced by the use of slow-action fertilizers.

KISS, A. S.: The one-sided or exaggerated use of fertilizers can be dangerous to the environment (to the health of man and animals), not only through run-off waters (leaching) but also through the accumulation of unchanged nitrates, nitrites and nitrose amines in the plants. Their methaemoglobinaemic and carcinogenic effects have been proved. Nitrogen fertilizers are apt to be washed out first, so the loss and contamination thus caused could probably be reduced by applying the top dressing in several doses.

KISS, Á.: Nutrient leaching caused by water erosion on areas with various degrees of slope, and even on sandy soils, is considerable (in the latter case because the nutrients pollute the ground-water). In every case this causes serious environmental pollution, so great care must be taken to prevent this from happening. Terraces must be built, and grass and trees planted. These same problems are endangering Lake Balaton, where it has now been found that care must be taken in developing artificial shores, and much greater attention should be paid to the maintenance and clearing of the original shorelines.

KOLTAY, Á.: The chemicals used in agriculture have become determining and indispensable factors of the modern production technologies. They cannot be dispensed with even on sloping areas exposed to water erosion, but their application in such places requires increased care. Water erosion and the leaching of nutrients must be reduced to a minimum by all possible means, particularly by ploughing along the contour lines and by fortifying the slopes.

KOVÁTS, A.: On sloping areas damage caused by water erosion must definitely be prevented. This is highly important from the point of view of both environmental protection and production; these interests are complementary rather than contradictory to each other. The effect of nutrients washed away will be lost, thus causing the efficiency of fertilization to decrease and the cost of production to rise. Land preservation also calls for the prevention of damage due to the erosive action of water.

To elucidate all the possible aspects of the question would require an analysis of the interactions of a great many factors, so I will confine myself to emphasizing that when fertilizing areas exposed to water erosion the overabundant application of fertilizers should be avoided and attention should also be paid to the method of application. The greatest loss, and thus the most serious environmental pollution, can be caused by the leaching of nitrogen fertilizers, while phosphorus may become a pollutant through the washing away of soil grains. This may increase the concentration of nutrients in standing waters. This danger does exist, though the environmental pollution caused by fertilization is, in my opinion, not as serious as it is usually thought to be. This naturally does not mean that the damage caused by water erosion should not be prevented by all the means available. Besides the strict observance of the special cultural practices required on sloping areas (cultivation along the contour lines, carefully chosen crops and plant varieties, etc.), increased attention should be paid to drainage, and to preventing flow-off water from entering lakes and rivers. Solutions of this description are particularly necessary in the hills surrounding Lake Balaton and the catchment area of the river Zala.

I should like to add that from the point of view of environmental protection the possibility of sewage and pesticides entering standing waters represents an even greater danger and requires still stricter measures to be taken.

LÁNG, G.: The effect of nutrient leaching caused by water erosion is greatest for nitrogen. Therefore, when deciding on the date and manner of nitrogen fertilization, environmental protection must also be taken into consideration, as well as the well-known tasks of soil conservation. In this way dangerous environmental pollution can be prevented.

LŐRINCZ, J.: Damage which may be done by water erosion can be lessened considerably by the method of cultivation. Since an adequate yield can only be expected if sufficient amounts of nutrient are supplied, a suitable quantity and composition of fertilizer cannot be dispensed with. Fertilizers leached or washed away only contribute to water pollution to a minor extent. The lack of public utilities, drainage and sewage purification causes more damage to the environment than the chemization of agriculture does. I suggest that the damage caused by erosion should be reduced by employing agro- and chemotechnics developed for this special purpose.

MIHÁLYFALVY, I.: In the case of plantations the per hectare consumption is 800—1000 kg mixed artificial fertilizer active agent. Some crop production systems suggest the use of 600—800 kg/ha. With such high doses of artificial fertilization on sandy soils and sloping areas nutrient migration and leaching out must be reckoned with. I consider this phenomenon to be extremely dangerous from the point of view of environmental protection.

In Hungary water quality standards are prescribed with regard to mineral content. For example, water intended for various uses can contain 13—30 mg/l ammonium.

As a preventive measure I suggest the compulsory carrying out of regular water and soil analyses on the areas concerned, and on this basis regulations for the purification of water and the evolution of a proper system of fertilization. Further, I suggest that the basic principles of agricultural technology on sloping areas should be strictly observed, and that the lower parts of slopes should be utilized for grasses or perennial papilionaceous crops.

MOLNÁR, J.: The rates of fertilization used at present cannot do any damage to the environment except on extremely exposed areas.

Too high doses should be avoided if only for the reasons given above.

In certain regions the application of chemicals requires increased methodicalness and competence (e.g. Lake Balaton).

NYÉKI, J.: On sloping areas, particularly in the fruit and vine regions of Transdanubia, where fertilizers are often used in excess, a considerable leaching of nitrogen due to erosion may occur.

Environmental pollution can, in my opinion, be prevented in several ways:

1) In vine and fruit plantations situated not far (500—600 m) from rivers and lakes the use of fertilizers should be controlled so that nitrogen is only applied in a quantity equal to that extracted by the crop (strictly controlled nitrogen balance).

2) Nitrogen fertilizers should be used which are not easily dissolved (Calurea, carbamide derivatives, etc.), or if readily dissolved fertilizers are used the farm should be obliged to carry out divided application.

3) On these areas careful, deep soil cultivation should be compulsory so as to prevent the water from running off the surface; the soil should be made capable of absorbing the largest possible proportion of the autumn and winter precipitation, and deep subsoiling should perhaps be carried out.

4) In the long run the threatened areas should be utilized by planting forests and groves which do not require fertilization.

PAIS, I.: I think nutrients are leached by water erosion to a considerable extent, and this represents an almost greater danger to the environment than the use of pesticides. The solution lies not so much in taking special measures as regards soil conservation and environmental protection as in supplying the fertilizers at the time and in the quantity required by the development of the plants.

PECZNIK, J.: The relationship between fertilization and erosion can be examined from two points of view. It is obvious that a soil well supplied with fertilizers and covered with vigorously growing plants is less exposed to erosion even on sloping areas than one with a low nutrient level and poor vegetation. At the same time, deposits washed off agricultural areas may cause considerable contamination to natural waters. Phosphorus and nitrogen compounds washed off into lakes play an indirect but important part in the process of eutrophization. It cannot, however, be said that fertilization is exclusively responsible for the process of eutrophization, since fens and peat formation are also the results of this process. The skilful application of methods elaborated for the protection of agricultural areas from erosion (cultivation along the contour lines, entrenchment, mulching, etc.), afforestation on areas particularly exposed to erosion and, last but not least, the protective effect of fertilization mentioned above may, in my opinion, bring satisfactory results from the point of view of environmental protection.

PETRASOVITS, I.: On sloping areas leaching caused by erosion may reach considerable proportions depending on climatic, hydrological, etc. conditions. Both on flat and hilly lands it is a source of both yield loss and environmental pollution (the latter mainly through the water). One way of preventing this, or at least of reducing it, is suggested by the water management conception elaborated at the Water Management and Melioration Department of the University of Agricultural Sciences, Gödöllő. The basis of the scheme is that each field should form an independent unit as regards water balance. At the same time a co-ordinated network of channels (to drain off the harmful surplus waters from farms and from larger areas), with the necessary structures and capacity must be ensured. The water balance of each field can thus be controlled, and the technical and agronomical conditions for soil conservation can be provided for. The requirements of both production and environmental control are thus fulfilled.

PLETSER, J.: Water erosion decreases the fertility of the soil by silting it and carrying the topsoil away. This loss cannot be made up for by fertilization, because if erosion protection is not carried out, only a fraction of the fertilizer will be utilized. Fertilizers which are carried off by the water and accumulate on low-lying areas reduce the yield, and the high concentration of fertilizers may even cause the plants to die. In addition, there is a threat that fertilizers carried to greater distances will pollute living waters.

It is a well-known fact that the damage caused by water erosion is the most serious on bare soils and the least dangerous on those covered by perennial fodder crops. The thinner the vegatation the higher the danger of erosion. Roads running parallel to the slope also increase the erosion. To this is added the angle of the slope, the quality of the soil and the climate of the region. From autumn to spring the soil is mostly bare. The sudden melting of the snow at the end of winter may also cause serious erosion damage. The water may carry away not only the topsoil but also the fertilizers distributed in autumn.

Methods by which erosion can be prevented are known. The most important ones are: soil cultivation perpendicular to the direction of slope, the sowing of crops which cover the soil to different extents in alternating strips and a serpentine road system. The extent to which these measures are necessary is determined by the topographic, soil and climatic conditions of the area to be protected.

Provided the protection against erosion is satisfactory, fertilization will be efficient and the living waters in the neighbourhood will not be contaminated.

POZSÁR, B.: Frightening and often dramatic reports are made not only on the eutrophization of Lake Balaton but also on the critically high nitrate and nitrite levels of groundwaters. The eutrophization of standing waters is primarily caused by phosphates and only secondarily by the nitrate level, and for the last ten years the organic production has shown an average increase of approximately one order of magnitude in Lake Balaton. In human and animal organisms, under the influence of Escheria coli infections, the nitrates are mostly transformed into nitrites which form complexes with the haemoglobin and may inhibit the oxygen exchange to such an extent that death may occasionally be caused in infants. In grown-ups the consequences are milder, but a number of metabolic indices may show a temporary sharp drop due mainly to a decrease in vitamin levels. The weight gain of farm animals slows down and consequently productivity and reprodction biology disorders occur. Furthermore, the nitrate and nitrite levels cause human toxicology problems just as important as the above owing to nitrosamine formation. (In the presence of nitrite nitrosamine may be formed spontaneously from secondary amines.) Nitrosamines, on the other hand, have carcinogenic and mutagenic activities owing to endogenous alkylation effects. It should also be pointed out that in products of animal origin (e.g. cheese) the level of nitrosamines shows a tendency to increase.

RAKONCZAY, Z.: In certain regions, e.g. in the area around Lake Balaton, nutrient leaching caused by water erosion is dangerous, in my opinion, from the point of view of environmental protection. Besides the measures already taken or those now in progress, I suggest the following:

In Hungary, and as far as I know in many other countries too, the traditiona branches of cultivation are taken more seriously than is justified and no change is thought to be possible. In Hungary this is clearly seen from the forest laws and from the legislation aimed at land preservation. There is a theory that wherever there is a forest it must be left there till the end of time, and where there are agricultural areas, there agriculture must be carried out. Although there are a few exceptions they are not characteristic. In this case the exceptions really do confirm the rule. Much as we respect the past and the traditions it must be admitted that the present areas of cultivation developed in many cases under the pressure of circumstances, and although they may have reflected an economic necessity at the time, it is not always present any longer. We have not given up thinking in terms of villages, districts and counties.

When the agricultural land preservation act came into force at the beginning of the sixties, it had to be executed within the village limits. This resulted in an awkward situation; e.g. in the northern part of the country very poor lands unsuitable for agricultural production were left under cultivation, while on the Great Plain large villages abundantly supplied with land, where there was also a shortage of labour, had to give up excellent agricultural areas for afforestation purposes.

To sum up, the nimbus surrounding the present branches of agriculture should be destroyed. Many forest areas could be reappropriated for agricultural use once they have served their purpose (e.g. in the case of cellulose poplars), while many agricultural areas should be used for forest plantation. This should be carried out on a national scale, not on a village, county, or worse still farm scale. For example, in some counties of the Great Plain (Békés, Szolnok) the agricultural area should be extended, while in other regions, such as the area around Lake Balaton, it should be reduced.

This method is feasible even within the areas under agricultural cultivation. On highly valuable areas exposed to erosion, and in the neighbourhood of lakes the relative proportion of croplands, orchards, meadows, pastures and vineyards could and should be changed.

With a view to environmental protection on the watershed area of Lake Balaton, preference should be given to forests and to crops which have a lower demand for chemical treatments.

SHMILLIÁR, M.: Water erosion, the washing away of the soil by water, has been occurring ever since the development of the soil surface. It only causes trouble where human shortsightedness, greediness or lack of skill have upset in some way the balance characteristic of the surface of the earth. The means of protection is self-evident: the balance must be restored, the surface operations should be chosen so as to slow down or prevent further erosion. The shaping of fields, the construction of roads, the plantation of forest belts, the direction of their longitudinal axes and the direction of ploughing and sowing are all factors that may influence soil conservation. In my opinion the question should not be put separately, because leaching can always be traced back to some fault made previously. If, however, the obligatory soil conservation is carried out with due care and appropriate methods, then the leaching of nutrients will not be significant.

SZALAI, GY.: With a view to the protection of the environment greater attention should be paid to the use of fertilizers on sloping areas (amount, distribution and ploughing in of the fertilizers). The neglect of these factors represents a serious danger to the living organisms in local waters. If harmful leaching occurs in spite of careful work, strips of grass 5—8 m wide should be established along the contour lines in the threatened areas. If necessary the rate of fertilization should be reduced in such places. The loss of income thus arising should be made up to the farm through state subsidization.

SZALAY, S.: It seems to me that the present management of fertilizers in Hungary is problematic. The cheap fertilizers produced with state subsidies may lead to careless storage and wastage and to unjustified damage to the environment. A characteristic example is the ever increasing danger of eutrophization in Lake Balaton, especially near the inflow of the river Zala.

SZENICZEY, Cs.: The leaching out of nutrients caused by erosion can be reduced somewhat by using fertilizers with a proper range of action and by using the correct soil cultivation and agrotechnical methods, but the protection of standing waters in the immediate neighbourhood of the catchment area is more feasible. The control of aquatic plants which proliferate as a result of a concentration of nutritive substances in the water is an easier task than the melioration of the total catchment area.

The need for a constant increase in the volume of food production inevitably causes a certain amount of damage to the natural environment.

SZÉKESSY-HERMANN, V.—FAZEKAS, S.: Damage caused by water erosion to soils with various degrees of slope was a problem even before the application of fertilizers. Then the loss of the topsoil was the main concern; since the introduction of chemization, losses in fertilizer efficiency and the toxic effect they have on the environment have been added. It is obvious that in the absence of any intervention the consequences of this damage will become increasingly severe as time goes on. To prevent this the use of organic manure is suggested either in combination with fertilizers, or applied separately from time to time. Organic manures of animal and plant origin ensure the many-sided replacement of the nutrient content of soil. But beyond this, what makes organic manure almost invaluable is the fact that its decomposition product is humus. Even now humus is regarded as the most important component of the topsoil, which maintains the soil structure at an optimum by means of the intensive complex-forming ability of the humic acid and related compounds contained in it, and through its advantageous property of being able to fix and store compounds of many transition metallic and non-metallc elements which are indispensable to the topsoil.

TARJÁN, R.: The use of fertilizers on areas with various degrees of slope requires special attention and skill in order to prevent certain components of the fertilizers from being regularly transmitted to lakes and rivers (or at least to reduce their quantities).

TUKACS, O.: This is a real problem which should be solved urgently because of its dimensions, its importance for the national economy and its implications for environmental protection.

In Hungary fluvial erosion (soil washed off by moving water) affects some 43,500 km^2, 47% of the territory of the country. Of this

858,000 ha arable area is slightly eroded (less than 30%),
885,000 ha arable area shows medium erosion (30—70%) and
554,000 ha arable area is highly eroded (more than 70%).

On eroded areas the crop yields decrease. According to the data erosion causes a yield loss equivalent to 900,000 tons of wheat a year.

Erosion also causes damage which cannot be expressed exactly in figures, that is, the damage done to nature itself, more precisely: to the noosphere, since the landscape represents the human environment which is transformed from a biosphere into a noosphere according to the social requirements. At the same time, the landscape not only ensures the material living conditions of the society, but is also the carrier of high-ranking esthetic values.

One type of damage caused by water erosion is the leaching of nutrients. In the case of artificial fertilization the nitrogen, phosphorus and potassium compounds are carried into standing waters either bound to soil fractions in the deposit or dissolved in the run-off. There they become concentrated and substantially change the quality of the water.

To the question of whether the extent of leaching is considerable only an approximate answer can be given, based on estimates. The leaching of nutrients can be determined for a given catchment area, but such calculations cannot give exact values owing to the interaction of numerous factors. For example, nitrogen does not only enter the soil in the form of fertilizers; the soil itself has a natural nitrogen content, originating from decayed plant and animal organisms and from the activity of nitrifying bacteria. Assuming an optimum ratio of nutrients the basis of calculation may be the difference between the amount of fertilizer supplied and that utilized by the plants, which is the amount which accumulates in the soil. From this amount the extent to which nutrients bound to soil grains are washed away can be computed by the equation set up by Wischmeyer—Smith for the estimation of general soil loss.

The calculation is still more complicated, and consequently less accurate, when the nutrient concentration in standing waters due to various industrial and communal wastes and to liquid manure is to be established.

Taking these difficulties into consideration let us calculate the per ha amount of nutrients washed away each year in the area of Lake Balaton in the case of an average soil erosion level of 25 ton/ha'year.

	N	P
from the original nutrient content of the soils	50 kg	9 kg
surplus after fertilizer distribution	7 „	5 „
surplus after ploughing the fertilizer in	1 „	0.5 „
total after fertilizer distribution	57 „	14 „
total after ploughing the fertilizer in	51 „	9.5 „

Not all of the amount calculated in this way reaches the water of Lake Balaton, but only 3.8% of it, according to Roehl's quotient for deposit transmission.

The data unequivocally show that the extent of leaching is significantly less when the fertilizer is ploughed into the soil after distribution. As much as 80% of the fertilizer may be washed away if it is not ploughed into the soil, depending on the intensity and duration of rainfall and on the time which has elapsed since the distribution. The situation is the same in the case of incorrect fertilizer storage. In Hungary only 9.14% of the fertilizers sold are placed in covered stores, and thus 15% of the active agent is lost.

From the point of view of environmental protection the nitrogen and phosphorus fertilizers are the dangerous ones. In the process of eutrophization the decisive factor is the presence of phosphorus, a minimum quantity of which is required, in contrast to the soil, where the minimum amount of nitrogen is the factor that determines the yield. Alga formation is particularly intensive in the presence of ortho-phosphorus. As a consequence of vegetal nutrients flowing into the standing waters the accumulation of nutrients accelerates, and as a result the aquatic plants overgrow and produce more organic matter than the heterotrophic organisms are able to utilize. The oxidation of the great mass of decayed plants require more oxygen than the vegetation can produce. Some plant species multiply at the expense of others. As a consequence of the changed flora the fauna of the standing water also changes, so a break occurs in the chain of nutrition, the biological equilibrium is upset and the eutrophization accelerates. The overgrowth of weeds in Lake Balaton and Lake Velence is the visible consequence of a deterioration in the quality of the water that has taken place during the last two decades.

For the growth of algae the mere presence of ortho-phosphorus in the water is not sufficient; the compound must reach the algae at a time when they can use it, that is, between April and August. Most of the fertilizers used in agriculture are not distributed during this period.

The average yearly amount of soluble ortho-phosphorus and total phosphorus found in the water of Lake Neagh, Northern Ireland, is not correlated with the volume of phosphorus fertilizers applied in the catchment area of the lake. In the case of nitrogen fertilizers, on the other hand, the investigations show a close correlation.

It can be seen from the above, that the fertilizers used in agriculture to increase the volume of yield also pollute the environment, even if the extent of pollution is not as great as it was thought to be in recent years. Prevention, control, and efforts to find a way of protection are the duties of society if the human race is to survive. In Hungary, where the property relations are nearly all approximately the same, the conditions for this are given:

- large-scale farming makes complex soil conservation and the uniform arrangement of catchment areas possible;
- the validity of laws, orders and regulations extends to soil conservation and environmental protection too;
- a state subsidy of 20—70% is granted for certain phases of soil conservation;
- there is an organized system for the research, planning and execution of soil conservation.

The problem is composed of two factors closely related to each other. Prevention and control can also be approached from two sides:

- the use of meliorative soil conservation methods to reduce erosion to an average 15 ton/ha/year, which is still in equilibrium with soil formation;
- the well-planned, skilful application of fertilizers.

Erosion can only be prevented or reduced by means of complex soil conservation methods and sensible farming on hilly and mountain areas, including all the organizational, planning, implementing and producing activities of the farms. I will not enumerate the classical meliorative, agronomical and technical methods of soil conservation, as they are well known. Based on the results attained so far in the control of erosion, complex methods of soil conservation should continue to be employed in the future, as far as this is financially possible, as they also take the tasks of environmental protection into consideration.

The amount of fertilizer to be used has been determined so far with a view to attaining as large a yield as possible. Fortunately, this view is now in the process of changing, and fertilizers are more and more often used in quantities determined on the basis of soil analyses. These amounts, when they are properly distributed and ploughed in, do not damage the environment. It was with this in view that the Plant Protection and Agrochemistry Centre and the Plant Protection and Agrochemical Stations were established; they have the duty of carrying out analyses once every three years not only for nitrogen, phosphorus and potassium but also for the macro- and microelements.

A method of determining the optimum rate of fertilizer application has been evolved by the researchers. The farms are also financially interested in this because of the increased prices of fertilizers.

The storage of fertilizers, on the other hand, leaves much to be desired for environmental protection and economic reasons alike. Fertilizers delivered in bags can be stored in the open for some time, but their use requires a great deal of manual labour. Bulk fertilizers can only be stored without loss and environmental pollution under cover. The construction of special fertilizer stores requires the investment of a considerable sum. But who is to bear the investment costs, the manufacturers, the wholesalers or the user? And if the cost is shared, in what proportion? These questions are still waiting to be solved. Even the simplest method of storage requires a solid (concrete or asphalt) foundation against infiltration, a minimum of side walls to prevent washing away, and a polythene cover, as is done in Austria.

The fertilizers used at present are readily dissolved in water, so the rain quickly washes them away or into the soil. Experiments are being carried out to produce and employ slow action fertilizers which dissolve in water with difficulty. At a lower nutrient level there is no significant difference between slow action and water soluble nitrogen fertilizers, but at a higher level of active agents the former have a better effect on the yield. From the point of view of environmental protection the introduction and general use of these fertilizers would be desirable in spite of the higher cost.

I should like to emphasize another important factor: human carelessness, which may be due to a lack of professional knowledge or may originate from negligence. As far as plant protection is concerned this problem has been solved: the farms are obliged to employ trained specialists and skilled workers. Any essential improvement in field of fertilization can only be expected from a similar solution.

To sum up: some of the fertilizers used on sloping areas are washed away, particularly when they are applied in large quantities. The environmental pollution they cause only appears indirectly, so they are potentially dangerous. The best means of prevention is to remove the source of danger. This can only be put into practice, however, for one of the components of this complex problem: erosion, which, on the basis of results attained and the methods developed so far, can be reduced to a considerable extent, depending on the financial means available. The use of fertilizers to increase the yield will be necessary in the future too, if the world population is to be supplied with food, but the rate and manner of fertilization must be determined by experts in order to prevent any damage to the environment.

TULCZ, I.: In my opinion, there may be considerable leaching of nutrients due to water erosion on sloping areas. For these areas special methods of fertilization should be elaborated, and their application should be supervised by the competent authorities.

On areas exposed to erosion increased attention should be paid to the use of nitrogen.

Increased stress should be laid, in my opinion, on contour line soil cultivation on sloping areas. It is very important to find ways of mechanizing the work on these areas, because soil cultivation along the contour lines offers great possibilities for protection against erosion.

*

Pál, Gy.: **Plants demand different quantities and qualities of nutrients in the successive phases of development. What is your opinion on divided top dressing? Does it have neither a quantitative, nor a qualitative effect on the yield (so that the necessary nutrients should be applied in one dose before sowing), or is it the most effective, but is not economical (so that the nutrients should be applied as basic fertilizers), or does it give the best results both quantitatively and qualitatively?**

Ács, A.: No clear stand can be taken on this issue. It depends on the plant species and on the kind of fertilizer. Phosphorus and potassium fertilizers have to be applied once, while nitrogen fertilization, especially in the form of NO_3, may be divided. For economic reasons I am all for application in a single dose.

The case of wheat fertilization requires special consideration; it might be justified to apply part of the nitrogen in autumn as basic fertilizer, and a smaller proportion once in spring, in the form of top dressing. In many cases divided application in later pheno-phases is not possible due to the development level of the plant. It is also uneconomical because of the losses caused by treading and because it involves substantial additional costs. Foliar nutrition carried out simultaneously with chemical pest control is also worth considering.

Baracs, J.: The question must be considered not only for each crop, but for each case separately.

According to our observations, and knowing the nutrient uptake of the plants, a divided top dressing seems to be more practicable and more economical, particularly as it can be combined with the protection of plants against fungal diseases.

Bauer, F.: As long as a farm uses small amounts of fertilizer, nitrogen can be supplied as a basic fertilizer under winter cereals in addition to phosphorus and potassium. On heavy soils all three should be ploughed in, whereas on sandy soils it is better to apply nitrogen to the ground surface. Nitrogen top dressing is thus only occasionally necessary to foster spring development. In the case of a high rate of nitrogen fertilization quantitative and perhaps qualitative aspects too may justify a divided nitrogen top dressing.

Beke, F.: At present it is impossible to give a general answer to the question. Under dry conditions and on heavy soils a single application is generally satisfactory. Under the opposite conditions many crops react better to divided fertilizer application. The plants have the highest water and nutrient requirements in the main growth period. If the necessary nutrients are not available in sufficient quantities during this period, this will have an impact on the yield. In such cases the divided application of fertilizers is of importance, but only if the nutrients reach the active root zone.

Beke, I.: Divided top dressing has an effect on the plant both quantitatively and qualitatively. From a physiological point of view the nutrients are best applied if and when they are needed by the plant. Of course, this refers to available and utilizable nutrients. This is best even from the point of view of economic efficiency, because in this case there is less likelihood of leaching and other losses. Nutrient deficiency and excessive nitrogen application may influence the protein composition and biological value.

In livestock breeding protein deficient feeding may result in the reduction of muscular tissues, while in crop production a shortage of nutrients may cause deficiency diseases.

The economic efficiency of correctly timed top dressing and foliar nutrition is no longer disputed in most farms.

Buzás, I.: In the different phases of development plants require a varying quantity and quality of nutrients. This much is known, but what nutrients are actually required, in what quantity and when, for the individual plant species (or varieties) under Hungarian conditions has not yet been established, so no generalizations can be made on a national scale.

Until this basic knowledge becomes available the reform of the traditional system of fertilization and the harmonious and continuous nutrition of plants may be discussed but cannot be put into practice, and the experimentation with divided fertilization is simply a case of groping in the dark.

Some experienced representatives of the profession have proved the advantages of divided fertilizer application in certain crops (primarily winter wheat) on the basis of practical results. These should be scientifically confirmed so that expert advice on how fertilization should be carried out could include this point too.

CSILLÉRY, M.: Observations show that the question of whether to apply the necessary amount of nutrient once in autumn before sowing, or on several occasions depends on the conditions of the current crop year.

Since the meteorological factors cannot be foreseen, the present practice is to supply nitrogen to winter wheat in two instalments, while with spring-sown crops the phosphorus and potassium, and 50% of the nitrogen are distributed in autumn, and the rest of the nitrogen is applied in spring before sowing.

After abundant precipitation in autumn and winter the crops are often striped in spring. This is the result not only of uneven fertilizer distribution but also of the leaching of nitrogen.

After top dressing in spring the stripes disappear and the wheat stand starts growing uniformly.

Top dressing by aircraft costs 90—100 Ft/ha which corresponds to the price of 30 kg wheat. This is not a large enough sum to be worth saving on and would in any case repay itself.

DEBRECZENI, B.: The question does not define the plant species or the kind of fertilizer concerned. Since top dressing is carried out exclusively with nitrogen fertilizers, and mostly in winter cereals, I shall only refer to these in my answer. Experiments and practical experience show that at the present average level of nitrogen application (150—200 kg/ha nitrogen), divided nitrogen fertilization (two-thirds in autumn and one-third in spring) is the most efficient practice as regards both the quantity and quality of the crop. According to our present knowledge, repeated nitrogen top dressing during the growth season is not always successful or economical.

HARASZTI, E.: The favourable effect of fertilization (top dressing) on the quantity and quality of yield when it is adjusted to the demands (development stages) of the plants has been reliably proved. The amount of fertilizers used for the different crops is decided taking the extra cost of distribution and the value of the expected yield into consideration. In our experience top dressing with 60 kg/ha nitrogen effective substance after grazing has given a satisfactory surplus yield in grass fields. Nevertheless, basic fertilization is necessary even in this case.

HARMATI, I.: One of the well-known basic conditions for attaining large yields is to satisfy the nutrient requirements of the plant continuously and harmoniously throughout the whole vegetation period. By applying the 300—400 kg/ha of mixed active ingredient generally required for wheat on one occasion this aim will not be achieved. With amounts as large as this divided application is the proper solution. This applies especially to nitrogen fertilizers.

In wheat production the use of 100—160 kg/ha nitrogen, depending on the precrop and the soluble nitrogen content of the soil, is justifiable. Ploughing this amount in all at once, in the form of basic fertilization, is not advisable for several reasons (considerable loss, over-development of wheat, etc.). In Hungary the overwhelming majority of the farms quite correctly distribute some of the necessary amount of nitrogen (40—50%) in the spring in the form of top dressing, mostly on one occasion. Experimental results show that nitrogen top dressing in the spring usually substantially increases the yield of wheat and improves its quality. The extent of this depends on:

1) the development level of the wheat late in the winter,
2) the soluble NPK and available water content of the soil,
3) the precipitation conditions during the vegetation period (especially immediately after top dressing),
4) the rate of top dressing,
5) the date(s) of top dressing,
6) the variety of wheat (susceptibility to fungal diseases and straw strength),
7) the type of soil.

In 1976 nitrogen top dressing on a single occasion (early in April) only resulted in a slight (0—5 q/ha) increase in yield owing to the extremely dry weather, while in 1977 it brought about a 5—18 q/ha yield increase depending on the variety, the soil fertility, the developmental stage of the plants and the rate of fertilization.

In 1977, for example, 100 kg N/ha applied as top dressing increased the yield of the variety GK Tiszatáj from 46.3 to 58.6 q/ha, while that of the variety GKF 2 was only raised from 86.6 to 90.8 q/ha.

In order to achieve a continuous and harmonious nitrogen supply to wheat, the application of nitrogen top dressing on more than one occasion in spring would be desirable. However, it was found that the second dose, generally distributed after shooting in the second half of April, did not always increase the quantity of yield, but rather improved the crop quality in our experiments. In spite of the fact that the wheat requires the most nitrogen in this period, nitrogen top dressing carried out at this time does not have the desired effect. The main cause of this is that the usually small amount of precipitation during this period is not enough to wash the nitrogen into the root zone. For this reason, and partly owing to technical difficulties, most of the farms carry out nitrogen top dressing on only one occasion. It is impossible to give rigid rules for nitrogen top dressing.

Good results have recently been attained by carrying out NPK top dressing on wheat in the autumn, or even better, in the early spring. Some 20–30% of the PK and 30–50% of the N requirement was supplied on these occasions. This solution looks promising, especially after winters with a lot of precipitation or when the crop is poorly developed.

HUSTI, M.: In my opinion divided top dressing has an influence on both the quantity and the quality of the yield. This can be explained by the fact that in certain phases of development the nutrient demand of the plant is higher. The plants must be helped through these periods with rapidly-acting fertilizers. The plants should be supplied with large amounts of fertilizer if large yields are to be produced. It is primarily nitrogen that causes trouble when applied in large quantities. If all the nitrogen active agent to be given to the wheat were supplied in autumn, the initial development of the crop would be too intensive, and a thick snow cover would create unfavourable conditions for the wheat. Fungal diseases do greater damage in an overdeveloped stand. An initial abundance of nitrogen may turn into nitrogen deficiency in the second half of the vegetation period.

The divided application of nitrogen is particularly necessary for winter cerals. Apart from an increase in yield, a better quality crop is obtained with this method.

KISS, A. S.: Both the quantitative and qualitative effects of divided top dressing are favourable, as observed in wheat (by applying nitrogen in the form of basic fertilization, then at tillering and before flowering). Both the quantity and quality of the yield (protein content, thousand-grain-weight), and consequently the fertilizer conversion, were found to be best in the case of divided fertilization. The better utilization of fertilizer in the case of divided nitrogen application might be explained by the decreased loss due to leaching. Divided top dressing is thus expedient.

KISS, Á.: Modern, divided top dressing, which takes into consideration the development of the crop, must be applied even if, for economic reasons, fertilizer distribution on one occasion is recommended. Divided top dressing gives better results both quantitatively and qualitatively, and is preferable from the point of view of environmental protection as well.

KOLTAY, Á.: The distribution of the full doses of phosphorus and potassium before sowing is still general practice, though an increasing number of experimental data show that they can be applied just as efficiently in the form of top dressing, e.g. in winter wheat.

In experiments carried out with winter wheat on a chernozem soil with forest residues at Martonvásár, NPK proved to have practically the same effect, averaged for years and varieties, when applied as a basic fertilizer or in the form of top dressing in spring. The optimum date for nitrogen application depends on a great many circumstances. The widely used method of supplying one-third or half of the total amount before sowing as a basic fertilizer, and the rest in the form of top dressing is quite safe. There are cases when the most successful method of application is to distribute the whole amount in autumn. On light soils and in winters with abundant precipitation spring application is justified by the danger of leaching. In experiments at Martonvásár identical amounts of nitrogen supplied to winter wheat in autumn (immediately before sowing), in three equal parts in the course of the winter, and on one occasion at the end of winter, proved to have practically the same effect. Yield differences due to the date of fertilization, and differences between divided and single dose application, were not significant.

According to the data obtained so far, on Hungarian soils, which are becoming richer and richer in available nutrients, the fractional application of nitrogen is not economical, and can, in fact, only be carried out satisfactorily by aircraft.

KOVÁTS, A.: The plant requires an adequate nutrient level to produce large yields, so the nutrient content of the soil must be raised to a level which will suit the needs of the plant. A distinction should be made, however, between phosphorus, potassium and nitrogen fertilization. The necessary amounts of phosphorus and potassium are applied in the form of basic fertilization and are ploughed into the soil, and in general care is taken to see that the soil is continually well supplied with these nutrients. Fertilizers containing nitrogen, on the other hand, are applied partly as basic fertilizer and partly in the form of top dressing.

According to experiments carried out in Hungary in regions with heavier soils or which do not receive too much rain in autumn and winter a large proportion of the required amount of nitrogen fertilizer may be distributed in the course of the autumn. On light soils or where there is heavy autumn and winter precipitation the loss of nitrogen accompanied by environmental pollution must be reckoned with. A divided application of nitrogen, some in autumn and some in spring, is therefore safer. This means in practice that 50—60% of the nitrogen requirement calculated on the basis of yield and fertilizer conversion analyses should be supplied in autumn. (On light soils even less than that.) The rest of the nitrogen is then applied in spring.

It is a well known fact that in wheat the undisturbed progress of organogenesis, the necessary number of spikelets and later a favourable number of grains per spike depend largely on the nitrogen supply. If there is a nitrogen deficiency fewer spikes with a lower number of grains per spike will develop. Thus, the question of repeated top dressing is closely related with the amount of nitrogen available for the wheat plant. Under the rather dry climatic conditions of Hungary top dressing early in spring during tillering has the best effect. It must also be taken into consideration that the soil is still cold at that time and therefore the process of nitrification is either totally suspended or very slow, hence the wheat does not receive sufficient nitrogen from the soil.

The effect of top dressing carried out later is largely a function of the precipitation. Wheat sown into a soil well supplied with nitrogen after a well-chosen pre-crop does not usually require further top dressing. If, however, a wheat crop previously well supplied with nitrogen suffers from a nitrogen deficiency when it begins to shoot, i.e. in the so-called intensive growth period, the number of grains per spike and thus the yield too will be smaller. Therefore top dressing during this period must always be carried out on the basis of the actual situation. It should be noted, that in the humid regions of Europe top dressing during this period is considered to be highly important.

By carrying out top dressing at flowering time the thousand-grain-weight, the protein content and to some extent the baking quality of wheat can be improved. The effect of top dressing at this time is highly dependent on the weather, however, and in dry years it cannot be counted on. This is why reports of experiments carried out in Hungary often speak of the ineffectiveness rather than of the positive effect of top dressing carried out late in the season. Success can be expected, on the other hand, from foliar nutrition performed in the same period.

In addition, I should like to underline the fact that under Hungarian conditions the quantity and quality of the wheat yield is determined not so much by divided top dressing as by a satisfactory supply of nitrogen. When a continuous nitrogen supply is ensured with the right pre-crop (e.g. peas) and by increasing soil fertility, the divided top dressing is of little importance, particularly in dry years.

KÜKEDI, E.: Under the soil and climatic conditions of Hungary the divided application of phosphorus and potassium fertilizers is not economical in most cases, since no significant difference which can be attributed to this can be observed between the yield averages. The date of PK application varies with the crop and the climatic conditions. With winter cereals the PK fertilizers can mostly be distributed on one occasion before sowing, in the form of basic fertilization. With spring-sown crops under arid conditions on chernozem-type soils phosphorus and potassium can also be supplied in the autumn. With spring-sown crops grown on sloping areas or light soils it is more favourable to carry out PK fertilization in spring, immediately before sowing.

The situation is slightly different in the case of nitrogen, which is a mobile, easily leached element. Although the yield averages of wheat, maize, green maize (sown thickly for use as fodder) and Sudan grass in experiments at Martonvásár did not show significant differences attributable to the divided application of nitrogen, the latter method, or top dressing with nitrogen are favourable for winter cereals for the following reasons:

- when large amounts of nitrogen are distributed on one occasion in autumn good conditions are created for autumn infections by the pathogens *Erysiphe graminis* DC f. sp. *tritici* Marchal, *Cercosporella herpotrichoides* Fron, *Fusarium* spp. etc.;
- on sloping areas and light soils losses due to leaching will be great;
- the stalks of winter cereals become highly elongated;
- when spring comes little or no nitrogen is supplied by the soil owing to the low temperature, so the cereals do not receive the amount of nitrogen necessary for rapid spring sprouting;
- the large doses of nitrogen distributed in autumn, which are not always calculated with the necessary accuracy, cannot be corrected in spring; etc.

For these reasons the divided fertilization of winter cereals is advantageous. On very dry areas, especially on chernozem and meadow clay soils, nitrogen can be applied at one go in autumn, but on any other type of area it is better to supply nitrogen to winter cereals in two or three doses. It can be applied in two doses on areas well supplied with nutrients, and after papilionaceous pre-crops. In this case the first distribution should take place right at the beginning of spring, while the second dose should be supplied at phenological stage G-H (on Keller—Baggiolini's scale).

Nitrogen can be supplied in three doses after pre-crops with unfavourable aftereffects, which leave a large mass of roots behind (maize, sunflower, Sudan grass, etc.), and when large amounts of nitrogen fertilizer are used. In this case the first dose should be distributed in autumn, and the other two at the dates mentioned above.

The divided nitrogen fertilization of spring crops is not economical in Hungary; nitrogen is best applied simultaneously with soil cultivation before sowing. However, on meadow and pasture areas, under irrigated conditions top dressing with nitrogen is advantageous and economical.

It can thus be seen that the division of phosphorus and potassium fertilization under arid conditions is not economical. Nitrogen, on the other hand, can advantageously be supplied in two or three doses to winter cereals. The top dressing of winter cereals late in the season with a view to improving the quality will not be worth considering until good quality is better rewarded.

LÁNG, G.: The advantage of divided top dressing varies according to the plant species and the growing site. For crops with short vegetation periods (spring barley) divided top dressing is obviously of no importance. Spring-sown crops with long vegetation periods (maize, sugar-beet, potato, etc.) are not responsive to divided top dressing either, partly because there is little likelihood that the nitrogen will be leached into the deep soil layers if it is applied at one go, and partly because the plant is not threatened by the danger that an abundance of nitrogen supplied at an early stage will cause disturbances in its development. Divided top dressing is most often justified for winter wheat in cases when the nitrogen-supplying capacity of the soil is naturally low, so that a high rate of nitrogen fertilization is required for the optimum nitrogen supply of the plant. Even in this case the direct benefit of divided top dressing is not always obvious, but nevertheless it has the advantage that the double fertilizer application compensates for the unevenness of distribution.

LŐRINCZ, J.: The nutrient uptake of plants is a highly differentiated and complex physiological process. The situation is different, for example, in the case of nitrogen uptake than when potassium or phosphorus are taken up. These phenomena can partly be followed with labelled elements. Future research may yield highly important results in this field.

I think divided nitrogen application, which may be combined with plant protection, is favourable for both the quantity and quality of yield. In the case of potassium and phosphorus the situation is different. These elements can be applied in a single dose or even for several years in advance.

MIHÁLYFALVY, I.: Under non-irrigated farming conditions I agree with the application of NPK on a single occasion except for a nitrogen top dressing in spring for crops sown in autumn, for perennial papilionaceous plants and for grasses. It is a generally known fact that in spring these types of plants are only able to utilize the nitrogen content of the soil at a certain temperature (when nitrification has started). The yield-increasing effect of nitrogen top dressing applied to these crops at the end of winter or early in spring has been proved both in experiments and in practice.

Under irrigated conditions, particularly in row crops, so-called supplementary fertilization during the vegetation period, either by ploughing the fertilizer in between the rows or by distributing it with the irrigation water, has proved more efficient than basic fertilization.

In our experiments on meadow and chernozem soils, fertilizers ploughed into the different layers separately were found to be more efficient than those introduced in a single layer.

Molnár, F.: In some crops the practice of divided top dressing has become general. The way in which plants respond to this type of fertilization varies; it dpends on the precipitation conditions and on the nutrient-supplying capacity and physical state of the soil. In soils with a high nutrient-supplying capacity divided top dressing has less influence on the plants. On soils with a poor skeletal structure (e.g. sandy soils) repeated top dressing is justified. The value of the components in plants grown on soils of this type improves under the influence of top dressing, and a healthier plant stand develops. In my opinion the nutrient supply of Hungarian crops is best ensured by a single top dressing on fertile soils, and with repeated top dressing on soils with a poor structure and low nutrient-supplying capacity.

Molnár, J.: The Bácsalmás State Farm uses the following method of winter wheat fertilization:

— phosphorus and potassium fertilizers are always distributed before ploughing;
— 50% of the nitrogen fertilizer is ploughed in before sowing with surface soil cultivation, 25% of it is supplied in the form of top dressing in November at the 3-leaf stage, and 25% at the end of February or the beginning of March at the spike differentiation stage. Earlier the farm carried out top dressing four times a year, which involved unreminerative extra costs.

In my opinion basic fertilization as the exclusive means of supplying nutrients is not good practice because of the danger of leaching involved, and because this makes the uptake of nitrogen less certain.

Nyéki, J.: This question is a function of the choice of fertilizers available on the market. In the case of spring crops there is no need for divided fertilizer application; in autumn crops it is generally successful.

From an economic point of view the omission of top dressing in spring is justified. In that case nitrogen fertilizers that dissolve slowly could be taken into consideration, so that the autumn and winter precipitation would not dissolve it. Considering that fertilizers possessing such properties are still expensive (production costs are two or three times as high), top dressing in spring, which has a considerable effect on the yield, will be necessary for a long time to come.

Pais, I.: The application of nutrients in a single dose before sowing is mainly a question of economy or habit. In theory this traditional manner of fertilization is undoubtedly wrong. The errors involved may be summarised as follows:

a) The nutrients necessary to the plant are supplied not at the optimum time, but usually 5—8 months earlier. This means there is a danger that some of the nutrients (particularly the nitrogen compounds) will be washed out of the soil and be lost to the plant.

b) The leached nutrients are carried into rivers and streams, where they disturb the established balance, with consequences which are almost incalculable.

c) Some of the nutrients introduced into the soil, particularly the water soluble phosphorus compounds and some of the substances containing potassium, become fixed in an insoluble form in the soil and are thus not available as nutrients to the plants.

d) From the point of view of the future I think it is highly dangerous that a considerable proportion of the phosphorus fertilizers produced from a highly restricted amount of raw material is applied too early and to no purpose. Later, when it is of decisive importance for the food supply of the world population there will not be sufficient raw material available for the production of phosphorus-containing fertilizers.

e) In current agricultural practice the application of nutrients to the soil simultaneously with the deep ploughing performed in the autumn is the simplest and cheapest solution, but with a loss of several hundred million forints a year it is doubtful whether it is really economical. Although not every nutrient can be supplied exclusively through the leaves of the plants, it has been proved scientifically that nearly the same effect can be attained in this way with a tenth or a hundredth of the traditional amount of active agent. With proper management the majority of nutrients can be mixed with most plant protectives, whereby the extra costs are substantially reduced.

PECZNIK, J.: When supplying the plants with nutrients, an attempt should be made to make the nutrients available in optimum quantities and ratios for the plants throughout the whole vegetation period, in accordance with their biological requirements (more precisely: in accordance with production aims). However, this requirement can only be more or less satisfied in hydroponic cultures. It is a well-known fact that the soil is not an ideal transmitter of nutrients. In the course of interactions between the fertilizers and the soil many processes take place which inhibit the favourable action of the fertilizers and change the environment in a manner disadvantageous to the nutrition of the plant. To mention just a few of these processes:

- the high salt concentration may hinder the water uptake of plants;
- the nutrient demands of plants cannot generally be satisfied exclusively by basic fertilization, nor can the optimum nutrient ratios be ensured in this way. The possibilities of top dressing, however, are limited;
- due to ion exchange the fertilizers may adversely alter the soil structure;
- the physiological reaction of fertilizers may shift the pH conditions prevailing in the soil in an unfavourable direction;
- losses due to various causes (leaching, denitrification, ammonia losses, etc.) may occur in the active agents of fertilizers introduced into the soil;
- some water soluble compounds (especially the orthophosphates) may be transformed in the soil into less readily soluble or even insoluble compounds, thereby becoming unavailable to the plants;
- the positive effects of microelements are only felt in a certain range of concentrations; at higher concentrations they may be poisonous, since they are mostly cell toxins. On the other hand, it is almost impossible to determine the optimum concentrations for the individual microelements, as they may either weaken or strengthen each other's effect, and they are also affected by the composition and reaction of the soil.

No further argument is required to make it clear that a divided application of nutrients generally provides more favourable conditions for the plant than when the whole amount of nutrient is supplied on a single occasion in the course of basic fertilization. Farm-scale experiments, however, do not always confirm the higher efficiency of divided fertilizer distribution. The contradiction can be traced back primarily to changes in the weather and to the differing soil conditions. Nevertheless, the results achieved with a more or less continuous (programmed) nutrient supply combined with trickle irrigation, for example, have proved the advantages of divided fertilizer application in practice too. The costs of top dressing can be reduced if nutrient supplementation is combined with other cultural practices (soil cultivation, plant tending, chemical plant protection, irrigation, etc.). Our own experiments show that the protein content of wheat can be increased and the quality of gluten improved by nitrogen top dressing (nutrition through the leaf) carried out late in the season.

Since top dressing (apart from foliar nutrition) means almost exclusively nitrogen fertilization, when so-called low-action N-fertilizers (e.g. carbamide-formaldehyde concentrates) are applied the total nitrogen requirement of the plant may perhaps be covered by basic fertilization. The results of investigations on this subject, including our own experiments, are rather contradictory, however, in addition to which the present high cost of low-action N-fertilizers also prevents their application in practice. A few preparations (e.g. Plantosan) are used in Hungary, but only in greenhouses or under polythene.

PETRASOVITS, I.: In our own experiments divided top dressing with lower than maximum doses gave the best results both quantitatively and qualitatively. However, on a farm scale this does not always coincide with either the possibilities or the economic optimum.

POZSÁR, B.: A divided top dressing complemented with regulators gives the best quantitative results, and its influence on quality is also the most favourable owing to the proper supply of nutrients.

SEMJÉN, I.: Plants require a different quantity and quality of nutrients in the successive phases of development. The experience gained so far indicates that the best results, both quantitatively and qualitatively, are obtained with divided top dressing. This statement holds true primarily for cereals, but top dressing carried out at various stages of development may give very good results in the case of sugar-beet, maize, and other crops as well. For wheat, divided nitrogen application is the right method under all circumstances. In autumn nitrogen should only be supplied as basic fertilizer in the case of decidedly bad pre-crops, and even then it must not be ploughed in deep, but worked into the shallow upper layer of the soil, as the nitrogen is easily leached if the autumn precipitation is somewhat heavier than usual.

In my experience the main dose of nitrogen (120—160 kg/ha) should be given to wheat at the end of winter, in February or March, in the form of top dressing. A further 50—70 kg/ha or so at shooting is also successful. Further top dressing at heading and flowering may be highly effective on occasion, depending on the state of development of the plants.

Maize is also responsive to nitrogen applied as a starter along the rows in addition to basic fertilization. A high rate of nitrogen fertilization is more successful in maize than in any other crop. In the case of sugar-beet nitrogen supplied in the form of top dressing at the 4—5 leaf stage also produces good results. Divided top dressing gives the best results both quantitatively and qualitatively, so this is the most economical method of fertilization.

SHMILLIÁR, M.: The question is not so simple, because it assumes the replacement of nutrients and combines it with one of the methods of distribution: top dressing. According to many years of practical experience fertilization is most efficient if the nutrient is applied in the following way. The amount of fertilizer to be supplied should be evenly distributed in the cultivated soil layer. This can be illustrated with an example. Suppose that the soil is being prepared for sugar-beet seed production after a cereal crop. The fertilizers should be distributed as a single top dressing before the stubble is stripped, before a medium deep ploughing to kill the weeds, and before a deep autumn ploughing, and should be complemented if necessary with foliar nutrition by aircraft. The latter can be combined with the simultaneous application of pesticides and stimulants, which today are preconditions for reliable large yields. The division of nutrient replacement in time and space increases the efficiency of fertilization.

The plant tries to develop roots where nutrients are to be found. If the nutrients are evenly distributed instead of being contained in large quantities in the same horizon, then the root system will develop uniformly throughout the whole cultivated soil layer. The development of the plant will be steady and the water supply ensured, so the plant will be more capable of resisting pests and pathogens.

SZALAI, GY.: With a 25—30 q/ha yield on loam and clay soils there was no difference in effectiveness between single and divided fertilizer application. At a higher level of production, however, the nutrient supply must be adjusted to the physiological properties of the plant. This can be achieved by top dressing and, above all, through foliar nutrition. In dividing the application of top dressing, however, the cost factor and the possibility of soil compression should be taken into consideration, so fertilization should not be divided too much. In foliar nutrition sufficient experience is not yet available with regard to the optimum date and number of applications. In Hungary this is the subject of further research.

SZENICZEY, CS.: The plant, like any other living organism, requires the different nutrients at a particular time, and in definite quantities and quality.

Nutrients should be given to the plant according to its biological requirements. At sowing time, for example, it makes no use of nutrients which will be necessary for emergence. The periodical application of nutrients according to the developmental stage of the plant is therefore more useful in spite of the surplus costs. This practice can be regarded as practically the most important means of controlling the quality.

TARJÁN, R.: With a view to optimum nutrient conversion and from the point of view of environmental protection the "good agricultural practice" of divided top dressing seems to be expedient, as foreign experience also shows. (E.g. the co-ordination of fertilizer and pesticide application.)

TOMPA, GY.: Top dressing is one of the most debated subjects in discussions on the nutrient supply of plants. It is an important operation, particularly in the case of cereals, as it may be a determinant of the yield. According to the present practice, phosphorus and potassium fertilizers are distributed and ploughed into the soil at the end of summer or beginning of autumn, after the removal of the pre-crop.

In this way the nutrient naturally goes to the bottom of the furrow where it will be located in a layer as deep as the depth of ploughing. After overwintering, when vegetation starts, the crop (in the present case winter cereal) needs immediate assistance, but its root zone is then near the surface and cannot make contact with either the phosphorus or the potassium. It is then that top dressing is of great importance, but not only with nitrogen: a fertilizer is needed which contains a complex of nutrients which become available to the plant in a short time even under the influence of a small amount of precipitation.

On the basis of the favourable experiences obtained in recent years our production system (KSZE) has elaborated the following method and made it an obligatory part of its technology. In the case of winter wheat it has already produced excellent results. The main point of this, in the case of wheat, for example, is to apply the fertilizer in two parts. The first step is the so-called basic fertilization, when 55—60% of the phosphorus and potassium, and 30—35% of the nitrogen is evenly distributed and ploughed down, or worked into the soil, depending on the pre-crop.

The second phase is the well-known "top dressing", when instead of one-sided nitrogen fertilization a complex "NPK" nutrient is supplied in such a way that the quantity of nutrient planned to be given in spring is distributed on two occasions.

The first, most favourable time of distribution is immediately after the end of winter, when vegetation starts; the amount supplied then is 50—55% of the total amount of fertilizer used for top dressing.

At the second fertilizer distribution (which is best carried out by aircraft to avoid treading) all the remaining fertilizer is applied. The optimum time for this work is between shooting and heading.

The beneficial effects of top dressing carried out in this way are felt even during the vegetation period. They manifest themselves primarily in increased growth vigour, standability, reduced damage and larger yields.

TULCZ, I.: Meteorological factors may greatly influence the effect of divided top dressing. Experience gained over many years shows that divided top dressing has a favourable effect on both the quantity and quality of yield. I think there are still great reserves in this respect, as the response of plants to top dressing has not been fully exploited. The use of helicopters enables us to adjust the distribution of fertilizers to the weather conditions and to carry out top dressing in cereals twice or even three times in a season.

*

PÁL, GY.: **As a consequence of intensive agricultural cultivation the plants extract increasing amounts of nitrogen, phosphorus and potassium from the soil, and at the same time considerably more organic matter of vegetable origin is left behind in the soil; the decomposition of this, according to our present knowledge, requires surplus nutrients, surplus nitrogen. In your opinion, should nutrients only be supplied to replace soil fertility by ensuring a nutrient level corresponding to the nutrient requirements of the plants, or should they be supplied at a higher level?**

ÁCS, A.: In answering this question a distinction should be made according to the species of plant in question. The root remnants of papilionaceous plants enrich the soil themselves. After crops with bulky roots containing large amounts of cellulose extra nitrogen application to eliminate the so-called "pentosane" effect is justified. The problem here is not only the decomposition of the roots, but also the often very large volume of stalk remnants (e.g. maize, wheat cut high) left in the field.

BARACS, J.: This question has been discussed a great deal in professional circles. PK accumulation in the soil to saturation level should be matter for thought not only for economic reasons. An excess of fertilizers may be fixed in an improductive way or become unavailable for the plant. Nitrogen is a mobile, non-accumulating nutrient, so the optimum dose, taking the decomposition of the organic matter content of the soil into consideration too, is easy to determine. A practice frequently encountered among growers is to apply fertilizers in excess of the calculated optimum amount on the grounds that the potential productivity of the variety will be better exploited in this way. This practice may cause phytopathological problems, especially in rainy weather, while in dry weather a wastage of fertilizers may occur; in the case of summer rainfalls ripening may take place later, which does not help in increasing the yield, especially not in cereals.

BAUER, F.: When a large quantity of organic matter is worked into the soil the surplus nitrogen required for the process of decomposition should be supplied. When nitrogen is applied subsequently, however, this surplus must be taken into account.

BEKE, F.: The efficiency of the nutrients supplied is in inverse ratio to the increase in yield. At a certain level (varying with the soil) a state of equilibrium is set up. Any increase in the rate of fertilization above this level causes a yield depression. Of course, in the course of the increased organic matter decomposition some of the nutrients supplied are used up. The lighter the soil (colloid state) the worse the efficiency (washing away, more intensive life in the soil).

BEKE, I.: The quantity of nutrients to be introduced into the soil should be determined so as to make sufficient amounts of mobile nutrients available for the plants in the successive phases of development.

It is not enough just to replace the amount of nutrient extracted by the crop; more nutrients must be applied than are necessary for the planned yield in order to make the required amounts available for the plant at any time during the growth season.

BUZÁS, I.: When speaking of nutrient replacement, it follows from the meaning of the expression that we think of the replacement of as much nutrient as was removed from the area with the main crop and its by-products. In this case it is implicitly assumed that the nutrient level of the soil is high enough to meet the nutrient requirements of the crop planned for the following year and that nutrients only need to be provided in a quantity sufficient to maintain the fertility of the soil.

If we do not want the soil fertility to decrease, replacement should be made even in this case with sufficient active agent to ensure that after the actual losses occurring in the soil (irreversible fixation, leaching, denitrification, etc.) the proportion left behind will be equal to the amount of nutrient extracted.

If the nutrient-supplying capacity of the soil is not sufficient to satisfy the nutrient demand of the crop planned for the following year, the nutrient requirements of the planned crop must be provided instead of replacing the amount of nutrient extracted in the previous year. To this end enough fertilizer must be used to enable the soil to supply nutrients in the amount and composition required by the plant.

Thus, the nutrient level is only in accordance with the nutrient requirements of the plant if it is able to satisfy fully the nutrient demand of the plant. It is not worth providing a higher nutrient concentration, since it is not the purpose of fertilization to attain as high a level of nutrient in the soil as possible.

DEBRECZENI, B.: The largest possible yield can only be attained if there is optimum co-ordination between the various production factors and conditions. More precisely, if optimum production conditions are assumed, the guarantee of a large yield is the scientific determination of fertilizer active ingredient ratios and economical rates of fertilization.

Many forms of fertilization extension service are encountered today in Hungarian farming practice. All the methods of calculation are fundamentally based on assessing the amounts of nutrient which can be extracted from the soil and on replacing them to varying extents. The term "balanced" fertilization means a method of supplying the plants with the amount of nutrient they need, while the available nutrient content of the soil is also maintained at a definite level. In other words, according to the principle of nutrient balance, the rate of fertilization must be co-ordinated with the size of the planned yield.

When planning the yield the climatic, soil, agrotechnical, etc. conditions that influence the crop structure of the farm also have to be taken into consideration.

Of all the factors which influence the nutrient requirement, agrochemists and practical crop growers take the following into account:

a) the nutrient demand and nutrient content of the plant;

b) the nutrients supplied by natural sources (the organic and mineral substances of the soil); other agrochemical properties of the soil;

c) the degree of fertilizer efficiency and conversion;

d) the influence of pre-crop, organic manure and green manure; and

e) the actual nutrient balance in plots with the correct nutrient content on farms carrying out regular fertilization.

The exact quantitative determination of these factors is a difficult task, since almost all of them are influenced differently by the local conditions (rainfall, cultural practices, soil, etc.), which have an effect on the quantity of yield, too.

Yet, if these factors are correctly judged, then the amount of fertilizer corresponding to but not exceeding the nutrient requirement of the plants can be ensured. Fertilizer application above this level may be particularly dangerous in the case of nitrogen, owing to a possible deterioration in quality, environmental pollution, etc. The question no doubt intends to refer to the recent method of replenishing the soil with phosphorus and potassium. I do not agree with the principle and method of replenishing the soil deliberately with phosphorus and potassium, because if the factors mentioned above are given due consideration fertilization carried out in accordance with the principle of nutrient balance will in any case lead to a gradual replenishment, even of soils poor in phosphorus and potassium, as proved by the following data on the national nutrient balance *for 1975, in 1000 tons:*

	N	P_2O_5	K_2O	Total
Given (inorganic and organic fertilizers)	629	466	665	1760
Removed (extracted by the crop)	475	202	505	1182
± ton	154	264	160	578
± %	32	131	32	50
Expressed as kg/ha agricultural area	+28	+44	+27	+97

This means that there is no need to accelerate this process artificially by using unreasonably large quantities of phosphorus and potassium fertilizers concentrated on certain areas. This would endanger the economic efficiency of fertilization and prevent the uniform distribution of fertilizers throughout the country.

Debreczeni, I.: With respect to intensive agricultural production including the question of fertilization, apart from phosphorus and potassium the role of nitrogen should, in my opinion, be given special attention. Phosphorus and potassium may become part of the mineral content of the soil. The phosphorus and potassium entering the soil with rich forms of vegetation (e.g. fen) have never caused any trouble to crop production. At the same time, the role of these elements in agricultural production is not as important as the role of nitrogen, for example.

One part of the ramifying nitrogen cycle set up by natural science is involved with agricultural production. Influence is exerted on this nitrogen cycle. The larger volume of agricultural produce resulting from a higher rate of nitrogen fertilization, and the consequent higher consumption of meat, milk and other protein rich foodstuffs are well-known facets of this process. On the other hand, the large amounts of nitrogen fertilizer applied cause water pollution which may ultimately result in problems with the drinking water supply. The World Health Organization together with the World Nutrition Organization were earlier of the opinion that the presence of 100 mg nitrate/litre of drinking water was harmless. Today this level is determined at 50 mg; moreover, in some countries 20 mg is considered to be the upper limit of harmless concentration.

In Hungary the permitted nitrate content of the drinking water, which was once 200 mg/litre, is today 10 mg/litre according to the standard MSZ 448/12.

A higher rate of nitrogen fertilization results in larger yields both within the farms and on a national scale. In the case of large yields the amount of nitrogen ploughed into the soil is always more than that contained in the crop. Is this surplus necessary? On the grounds of the above it seems that it is. I should like to support this statement with a few data from the more or less general 1975 nitrogen balance of Hungarian agriculture.*

In Hungary the amount of nitrogen contained in the yield of grassland areas in 1975 was 122.7 kg/ha, a total of 701,477 tons. The volume of nitrogen introduced into the soil in 1975 by fertilization and in other ways was 130.0 kg'ha. A comparison of the two data reveals that in 1975 the nitrogen content of the soil increased by 7.3 kg/ha.

On the basis of the average figures the increase in the nitrogen content of the soil in Hungary today is so slight that it cannot represent any danger. Considering that this balance has only recently become positive, after being negative for years, it may even be that abundant nitrogen fertilization, that is, ploughing more nitrogen into the soil than is contained in the crop, satisfies a need.

However, the order of magnitude of the individual items of the nitrogen balance suggests a certain kind of wastage (Fig. 1). Each hectare of area is given 41.7 kg nitrogen

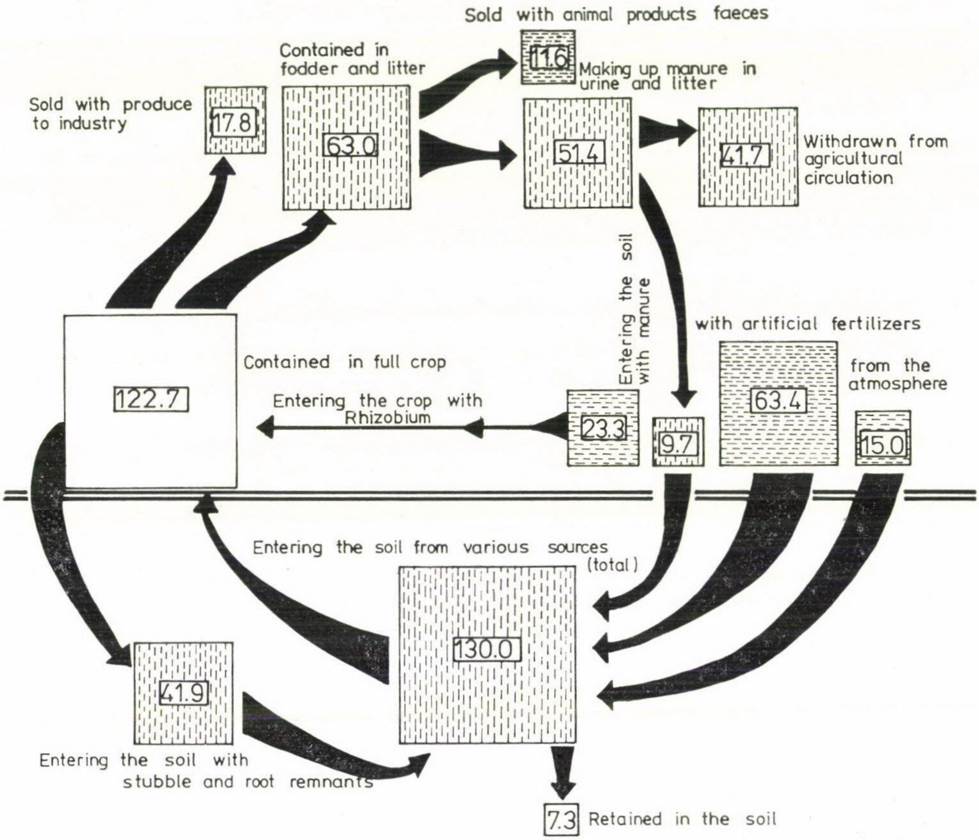


Fig. 1. Combined nitrogen balance of major field crops and grassland areas, and the distribution of the individual items in Hungary, 1975

* István Debreczeni: Fontosabb szántóföldi növényeink és gyepes területeink együttes nitrogén mérlege (Joint nitrogen balance of major field crops and grassland areas in Hungary). Növénytermelés. (In press.)

which is withdrawn from farm circulation. This is due to the following. The crop of one hectare contains 122.7 kg nitrogen. The amount of nitrogen returned to the soil with stubbles and root remnants is 41.9 kg; that sold as food or to other industries is 17.8 kg; and the quantity retained in fodder and litter is 63.0 kg. Of the nitrogen contained in fodder and litter 11.6 kg is sold with animal products while 51.4 kg is collected in the manure gutters. This causes a break in the circulation, which starts anew with the amount of nitrogen added to the soil in manure, which is 9.7 kg/ha. The rest, the aforementioned 41.7 kg/ha nitrogen, is withdrawn from farm circulation.

Győri, D.: In my opinion, nutrients should be supplied in a quantity exceeding the nutrient requirements of the plants by 10—20%, because the soil can only be made more fertile by increasing the biological cycles of mineral nutrients. From this point of view, of course, not only fertilizers but also liquid manure and sewage (without heavy metal and radioactive contamination) are of importance.

Haraszti, E.: I think an extra amount of nitrogen fertilizer should definitely be supplied to the soil to decompose the organic matter, containing mainly carbohydrate, left behind in the soil. This opinion is supported by practical experience obtained in Hungary. Organic matter decomposition should, however, be promoted by appropriate cultural practices, so that the extra amount of nitrogen fertilizer used for this purpose can be reduced as much as possible.

Table 1

Population trends in the world, in Europe and in Hungary between 1930 and 1970

Year	Population, million		
	World	Europe	Hungary
1930	2070	504	8.685
1940	2295	540	9.316
1950	2517	536	9.293
1960	2982	589	9.961
1970	3635	645	10.322

Year	Increase relative to 1930		
	World	Europe	Hungary
1930	1.00	1.00	1.00
1940	1.10	1.07	1.07
1950	1.21	1.06	1.07
1960	1.44	1.16	1.14
1970	1.75	1.27	1.18

Harmati, I.: In my experience, nutrients should be supplied to the plant beyond its requirements. When deciding on the extent of this, however, the nutrients must be considered individually and economic aspects should also be taken into consideration.

The optimum nutrient level of the soil is influenced not only by the type of soil but also by the available water content. Since the water level is constantly changing, the optimum nitrogen content is that which suffices even under drier conditions, and this is higher than that required in rainier weather. This higher nutrient level is justified by the need to provide the right nutrient concentration in the soil towards the end of the vegetation period, as well as by the need for a continuous supply of nutrients. This

Table 2

World trends in the yields of some major crops between 1930 and 1970

Year	Yield, 1000 tons			
	Wheat	Rice	Barley	Maize
1930	131,512	90,700	42,950	100,461
1940	148,281	131,763	59,700	126,000
1950	166,600	160,900	57,745	145,500
1960	243,700	239,700	93,000	222,700
1970	318,437	308,767	139,551	261,312

Year	Increase relative to 1930			
	Wheat	Rice	Barley	Maize
1930	1.00	1.00	1.00	1.00
1940	1.12	1.45	1.38	1.25
1950	1.26	1.77	1.34	1.44
1960	1.85	2.64	2.16	2.21
1970	2.42	3.40	3.24	2.60

is important, among other reasons, because at that time of the year the water level in the soil is generally lower. The utilization of the water content of the soil is also much better in the case of an abundant nutrient supply. Thus it is not enough to ensure a nutrient level corresponding to the nutrient requirement of the plant.

When determining the optimum nutrient level, the three macronutrients must be treated differently.

The amount of nitrogen applied must not be much higher than the requirement. According to rough estimates, about one and a half times the requirement should be sufficient during the vegetation period. With a view to protection from drought, sufficient quantities of soluble nitrogen should be contained in the deeper soil layers, too. When determining the optimum amount of nitrogen, however, the soluble phosphorus content of the soil must also be taken into account to ensure the proper ratio.

The phosphorus and potassium levels of the soil can be safely set much higher, since an abundance of these elements does not cause any damage to the plants. Furthermore, these nutrients, particularly phosphorus, are not leached out of the soil, so the quantities can be increased from year to year.

In my opinion, however, it is debatable whether the rapid replenishment of the soil with phosphorus is either possible or economical. Phosphorus becomes more or less bound in the soil depending on its pH value and hydrolytic acidity, and will be unavailable to the plant. Replenishing the soil with phosphorus and potassium to a fairly high level is reasonable and feasible, but this is better carried out gradually. According to the results of experiments carried out on a calcareous meadow soil poor in phosphorus, no significant differences were found over the average of three years between yields obtained with PK supplied once for the 3 years or distributed year by year. The gradual supply of phosphorus proved to be more favourable.

Kiss, Á.: This question is closely connected with the second question. We should beware of applying above-optimum fertilizer rates. Environmental protection must never be neglected. In my opinion, the excessive, above-optimum use of fertilizers is harmful.

Kováts, A.: If crop production is to be reliable the soils must gradually be replenished with phosphorus and potassium until they are well supplied with these elements. Some of the soils in Hungary (about 50%) are well supplied with potassium. In consequence of a high rate of phosphorus fertilization some fields have an adequate level of phosphorus too. Under these circumstances fertilizers only need to be applied in accordance with the nutrient requirements of the plants. However, on sites where the required nutrient level has not yet been attained an attempt must be made, depending on the financial resources of the farm, to replenish the soil by supplying nutrients in quantities larger than those required by the plants. This is the first step. Later the soil may be further replenished, particularly with phosphorus, beyond the nutrient requirements of the plants. This no longer serves to increase the yield, but offers security in periods when the phosphorus supply may perhaps be limited to the reserves in the soil (due to the world market situation, for instance). At the same time, nitrogen should, in my opinion, be supplied according to the requirements of the plant.

KÜKEDI, E.: The amounts of phosphorus and potassium to be applied are calculated on the basis of the amounts of PK active agents extracted by the plants and that contained in the soil. Data on the nutrient demands of different crops are found in tables constructed for this purpose, while information on the nutrient contents of soils are given by the results of soil analyses. The amount of PK nutrients required by the plants can be calculated by multiplying the planned yield (q) by the quantity of PK extracted (kg) by 1 q crop. Winter wheat, for example, extracts 1.2 kg P_2O_5 and 2.2 kg K_2O from the soil to produce 1 q grain and straw yield. Thus, for a 50 q yield 60 kg/ha phosphorus and 110 kg/ha potassium active agents are required. This is the total PK nutrient demand of wheat. This is not, however, identical with its fertilizer demand, as the latter varies according to the PK content of the soil. As regards the phosphorus content of the soil the following groups can be set up:

Low phosphorus content (an average of 10 mg P_2O_5/100 g soil)
Medium phosphorus content (an average of 11—18 mg P_2O_5/100 g soil)
High phosphorus content (an average of 19—35 mg P_2O_5/100 g soil)

Very high phosphorus content (an average of above 35 mg P_2O_5/100 g soil). (The lower values refer to light, the higher ones to heavy soils.) Knowing these data the phosphorus fertilizer demand of wheat or any other crop can be determined. The corrections are made as follows:

With low P contents the extracted P + 90 kg/ha active agent
With medium P contents the extracted P + 40 kg/ha active agent
With high P contents the extracted P + 10 kg/ha active agent
With very high P contents the extracted P alone.

Potassium doses are calculated in a similar way, on the basis of the amount of active agent extracted by the plant and the potassium content of the soil. The total yield (q) planned for the different crops multiplied by the amount of potassium (kg) required for 1 q yield gives the K-active agent requirement. When determining the fertilizer requirement the value thus obtained needs correction. Alterations are made on the basis of the potassium content of the soil. The following groups can thus be distinguished:

Low K-content soil (an average of 11 mg K_2O/100 g soil)
Medium K-content soils (an average of 12—24 mg K_2O/100 g soil)
High K-content soils (an average of 25—40 mg K_2O/100 g soil)
Very high K-content soils (an average of above 40 mg K_2O/100 g soil).

(Lower values refer to light, higher ones to heavy soils.) Taking the above nutrient levels into consideration the potassium fertilizer requirement of plants will be:

on low K-content soils the extracted K + 120 kg/ha K_2O,
on medium K-content soils the extracted K + 50 kg/ha K_2O,
on high and very high K-content soils only the extracted K should be replaced.

Besides the above method of calculating the fertilizer requirement there are naturally other methods too, but they are all based on the nutrient demands of the crop and the nutrient content of the soil. The above method has the advantage of rendering it possible to replenish areas poor in phosphorus and potassium, while maintaining the level of these nutrients in other soils.

To determine the optimum rate of nitrogen fertilization, however, is much more difficult, as both too much and too little nitrogen are disadvantageous, because they reduce the yield. The situation is made more difficult by the fact that soil analyses only record the momentary conditions and do not give any information about changes, although it is well known that the nitrogen content of the soil changes much more quickly than the phosphorus and potassium contents. For these reasons it is mainly the amount of nitrogen extracted by the plants that is taken into consideration when calculating the necessary rate of nitrogen fertilization. The necessary active agent is again given by the product of multiplying the planned yield (q) by the quantity of nitrogen (kg) required for 1 q crop. The nutrient requirement thus obtained is then corrected. The N active agent of any farmyard manure that may be used that year, the pre-crop, the nitrogen level of the plot, the type of soil, the disease susceptibility of the crop in question, the tendency of cereals to lodge, etc. are also taken into consideration.

After pre-crops which leave a large mass of roots behind with an unfavourable composition (sunflower, sorghum, maize, etc.) an extra 0.7 kg N/q stalk residue is supplied.

To sum up what has been said, the replacement of phosphorus and potassium is carried out taking into consideration the quantities of these elements extracted by the plants and the amounts contained in the soil. When determining the rate of nitrogen fertilization, first the amount of nitrogen extracted by the crop, and then the nitrogen level in the soil of the plot, the pre-crop, etc. are considered. In replacing the nutrients the main aim is to replenish soils poorly supplied with NPK and to maintain the good condition of soils rich in nutrients.

LÁNG, G.: At an intensive level of fertilization the decomposition of the organic matter left in the soil does not generally require surplus nitrogen application. Phosphorus and potassium should be supplied either according to the nutrient requirement of the plant, or possibly at a higher or lower rate, depending on the natural nutrient-supplying capacity of the soil. At present most soils definitely need to be supplied with phosphorus if large yields are to be obtained, so the distribution of a quantity exceeding the requirement of the plant is advisable. Even in soils rich in phosphorus this element should be supplied in quantities exceeding the amount of phosphorus extracted by the plant, and should only be reduced to the extracted amount as a temporary measure, if at all. Under Hungarian conditions, with potassium fertilization the natural potassium-supplying capacity of the soil can be counted on even in the case of intensive agricultural production, and an amount of potassium smaller than that extracted by the plant can be applied. But in this case the potassium-supplying capacity of the soil must be checked with special care lest the potassium be reduced to a minimum.

LŐRINCZ, J.: A nutrient surplus, which is required for the decomposition of the organic matter left in the soil, always requires consideration. This is all the more important as fertilizers also have a greater effect in a soil rich in organic matter.

In my opinion the fertilizer surplus required for the decomposition of the organic matter left behind in the soil must always be ensured.

The soils passed down to our children and grandchildren must not be poorer in nutrients than those we received from our fathers. I think that this point should be taken into consideration in each case when replacing the nutrient content of the soil.

MIHÁLYFALVY, I.: When the whole above-ground crop is ploughed into the soil extra nitrogen application is required for the decomposition of the large masses of organic matter. In other cases the artificial fertilizer supply should be adjusted to the nutrient requirements of the crop. If artificial fertilizers are to be better utilized and more complete and quicker decomposition of organic matter is to be achieved, greater attention should be paid to rational soil cultivation.

MOLNÁR, J.: If regular soil analyses are carried out every two or three years it can be determined after a few examination cycles whether the P_2O_5 and K_2O levels calculated on the basis of the physical properties (structure, viscosity) of the soil are realistic. The amount of nutrients supplied in the meantime and that extracted with the crops must be known for the evaluation. If the balance is positive and the amount of nutrients in the soil has reached the desired level, then overapplication must stop, and only the nutrients required for the expected yield should be supplied.

If the level of nutrients in the soil is not satisfactory, phosphorus and potassium must be supplied beyond the amount required for the expected yield, at such a rate that the soil will reach the required nutrient level as soon as possible.

NYÉKI, J.: It is not only by the amount of grain, straw, root, tuber and green plant parts, which can be directly expressed in figures, that the effect of fertilization can be assessed, since when larger yields are produced a proportionately larger quantity of root remnants are left behind in the soil. This is where the after-effect of fertilization is to be found. In soils containing large amounts of nutrients the organic matter turnover will also be intensive, and consequently, even if occasionally fertilizers are not applied for a year the yields will probably not be reduced at once. In order to maintain a high yield level and steadily exploit the yield potential the quantity of active agent used should always be at least 10—15% more than what the plants extract from the soil. If this is not done the possibility of obtaining surplus yields is lost and the maximum productivity of the new varieties will never be known. What would happen if the amount of nutrients required for the Bánkuti wheats were to be applied today?

PAIS, I.: If we possessed a totally reliable balance for measuring nutrient dynamics, it would be advisable, on the majority of soils, to use just enough fertilizer to restore the fertility of the soil, that is, to cover its nutrient requirements. With a slight exaggeration it might be said that the soil only serves to "hold the plant". This rather strange statement applied primarily to the poor quality sandy soils which are quite frequent in Hungary.

PECZNIK, J.: Nitrogen-deficient organic matter of vegetable origin (stubble and root remnants of non-papilionaceous crops, straw, maize stalks, etc.) may cause a temporara shortage of nitrogen in the soil (pentosane effect). The high ratio of C : N can only really be corrected with surplus nitrogen application, but the amount of nitrogen to be used will only be significant if straw or maize stalk fertilization is carried out, as shown by our own experiments, where, although the results were rather ambiguous, this method improved the fertility and structure of the soil and made it easier to cultivate.

Increasing the nutrient level of the soil by replenishment fertilization is a different matter. The high nutrient content of the soil is undoubtedly one of the preconditions for attaining high yields. Recent experience indicates that in Hungary the nutrient level of soils subjected to intensive fertilization has been substantially raised, which means that the amount of nutrients applied by the farms has been considerably greater than that extracted by the plants from the soil. Of course, the question also has an economic side: owing to the price support granted to fertilizers, replenishment fertilization may be economical for the farm, but is not necessarily so for the national economy. A further objection to replenishment fertilization is the possibility of greater nutrient losses (leaching, erosion, retrogradation of phosphorus compounds, incorporation of potassium ions in the crystals of clay minerals, etc.). All in all, in my opinion no objections can be made to a rational raising of the nutrient level of soils, since this may also provide safety reserves for the coming years, but naturally all the points raised above must be taken into consideration.

PETRASOVITS, I.: It is very difficult to answer this question in general, for any time and place One must always try to find the ecological and economic optima.

In officielly approved food production the upper limit of fertilization, i.e. the ecological optimum, is the amount of nutrient which is just not enough to reduce the yield. Alternatively, the ecological maximum may be the point where an increase in the amount of nutrients still results in an increased yield. On profit-making farms the limit of nutrient utilization is the economic optimum (where a further nutrient supply will not decrease profitability, nor impair the input-output ratio).

POZSÁR, B.: In the German Democratic Republic, unlike the other socialist countries, the optimum level of nutrients has been ensured by a medium rate of fertilization since the middle of the fifties. It can be regarded as a consequence of this that the GDR was the first to obtain record wheat yield averages in the sixties.

SEMJÉN, I.: The soil should be supplied with nutrients in quantities exceeding the requirements of the plants *(ad libitum)*. Phosphorus and potassium should be used in large amounts, for several years in advance, partly because large doses can be relatively evenly distributed with the present technical means, and partly because these two nutrients take a long time to become available to the plants. This is why divided application is uneconomical in this case.

Nitrogen, on the other hand, which quickly escapes or is washed off, must be fed to the plant in small doses. However, in the case of wheat excessive nitrogen fertilization may be dangerous as it causes lodging. Under droughty conditions, on the other hand, it mainly promotes the vegetation. In maize, nitrogen supplied in excess of need brings results. By increasing the assimilating surface it helps the plant through the most severe droughts.

Maize is the only plant which tolerates almost any amount of nitrogen and what is more, makes good use of it. For example: during the 1977 drought 400—500 kg/ha nitrogen resulted in 80—100 q/ha yield of maize, while with 200 kg/ha nitrogen the same varieties grown under the same conditions only gave a 50 q/ha yield. From the surplus amount of nitrogen the maize plants were able to take up the nutrients required for the larger yield even under the arid conditions, at a low level of soil moisture. With a satisfactory assimilating surface and better vegetation, the productivity inherent in the variety was more strongly manifested. This region generally has a low amount of precipitation, so the use of surplus nutrients gives security.

Shmilliár, M.: I have already expressed my opinion on this subject, so I will only note here that nutrients should be supplied beyond the nutrient requirements of the plants. Great attention should be paid to the undisturbed life of the soil and to the restoration or maintenance of a nutrient balance in the soil, so as to prevent the chemical and physical properties from deteriorating in good quality soils and to improve them in poor soils.

Szalai, Gy.: Crops should be fertilized according to their nutrient requirements; fertilizers must not be supplied beyond this extent, unless this is done for a definite purpose. This "definite purpose" may be the elimination of the pentosane effect, or the filling up of the soil with nutrients (in the case of low nutrient levels), etc. In a rational system of farming this must also be considered, but, I repeat, only to a certain reasonable extent, and taking other circumstances (mechanical structure and organic matter content of the soil, topographic conditions, etc.) into consideration.

Szalay, S.: The organic matter left in the soil with the roots is welcome, because when it is humified it improves the physical structure, water regime and ion exchanging properties of the soil, and may promote the multiplication of nitrifying bacteria and thus the fixation of extra nitrogen from the air.

Szeniczey, Cs.: Applying fertilizers in the form of basic fertilization is only profitable, in my opinion, if this is done just sufficiently to restore the fertility of the soil. Subsequent nutrition should be carried out in accordance with the requirements of the plant. I consider the "storage" of fertilizers in the soil to be incorrect practice. Under extreme climatic conditions this may cause serious problems, not to mention the aspects of environmental protection referred to above.

Tompa, Gy.: Today it is generally accepted that if the right varieties are used "plant nutrition" is one of the most important factors influencing the yield. This is one of the reasons why it is very important for the farms to ensure a continuous nutrient supply to the soil. Expert advice on how this should be done is given by the agrochemical stations which have been established all over the country.

In determining the quantitative requirements for the major components (NPK) the following method, based on the principle of replenishing the soil, should, in my opinion, be employed.

a) In the first step, depending on the results of nutrient analyses, the soils should be replenished with P_2O_5 and K_2O to a level that ensures the maximum yield, taking all the other factors into consideration.

b) If the amount of either phosphorus or potassium contained in the soil exceeds the desired value, the level of the component which is present in a lower amount is adjusted according to the value of the other component, so that the optimum potassium: phosphorus ratio is restored.

c) In the following years the amount of nutrient extracted by the pre-crop must be determined taking both the main and by-products into consideration, and must be subsequently replaced.

d) In determining the nitrogen requirement the percentage of nitrogen extracted by the plant is multiplied by the expected yield. This rough value must of course be corrected, and the effect of the pre-crop, the N-supplying capacity of the soil, and the date and amount of organic manure application must be changed in a positive or negative direction as required.

I am sure that if the soil were properly replenished with nutrients, the yields produced would be far more consistent.

TULCZ, I.: The method of fertilization depends on the nutrient level of the soil. The soil must be replenished to a given level as soon as possible, and subsequently fertilizer should be supplied in excess of the nutrient demands of the plants, since the efficiency of fertilization is influenced by various factors. The extra dose of fertilizer which is required for the decomposition of the root and stalk residues left in the soil must definitely be applied.

*

PÁL, GY.: **The size of the irrigation area in Hungary is 425 thousand hectares at present and is growing from year to year. On this area incorrect methods of irrigation may result in the fertilizers being washed out, while proper irrigation promotes better utilization. In your opinion is the extent to which fertilizers are washed out of our irrigated areas insignificant, is it compensated by better utilization, or is it too great to be balanced by better utilization?**

ÁCS, A.: The danger and extent of leaching depend on several factors: the method of irrigation, the amount of irrigation water, the physical properties of the soil, the level of the area, the kind and quantity of fertilizer applied — to mention only the most important ones.

Leaching certainly causes damage which must be prevented. Methods of irrigation should be used where the only function of the water is to dissolve the nutrients in the fertilizer and make them available to the plants, without setting the solution in motion. Both the amount and manner of application of irrigation water should be controlled. Dripping irrigation through a perforated hose laid on the ground, for example, seems to be a good method of irrigation. Leaching can thus be either negligible, or balanced by better nutrient utilization, or of a dangerous extent, depending on the circumstances.

BARACS, J.: Properly applied irrigation is definitely an indispensable factor for yield stability. Its adaptation to different crops naturally requires very precise advance calculations. In the rather dry year of 1976, for example, the average yield of potatoes on the 370 ha irrigated area of the Szentlőrinc State Farm was 350 q/ha when 120 mm irrigation water was used, while the "Béke Őre" Co-operative Farm at Somberek, where all the other technological requirements were strictly observed, harvested only 200 q/ha potatoes without irrigation. The difference was thus 150 q/ha in favour of the irrigated crop, which meant about 40,000 Ft additional income for the state farm compared to the co-operative farm. By adapting the irrigation to the soil and distributing a carefully calculated amount of fertilizer the yield averages can be considerably increased, though there is a constant danger of leaching; this, however, can be lessened by applying substantial amounts of organic matter.

BEKE, F.: The better water utilization of irrigation systems and the higher productivity of irrigation water depend on a harmonious nutrient supply. Unfortunately, wasteful nutrient utilization and the consequent danger of environmental pollution are encountered in many places. Irrigation is inexpertly managed in most farms.

BEKE, I.: As a result of incompetence a considerable amount of fertilizers is leached on the irrigated areas. In Hungary up-to-date surface irrigation systems only cover a small area, and optimum geographical conditions from the point of view of irrigation are only found on a limited area.

The technical and human aspects of sprinkler and trickle irrigation have not yet been solved, and with extensive crops the economic efficiency of these irrigation methods may in fact be disputed.

With skilful irrigation the extent of leaching is negligible, and the conversion of fertilizers is better.

BUZÁS, I.: In Hungary, within the framework of the first large-scale irrigation programme after World War II, areas which were almost totally infertile were equipped with irrigation facilities.

Later, when designing the irrigation systems of the Tisza II barrage, quite different aspects were taken into consideration. Irrigation proved to be the most economical with soils which were already the most fertile. Furthermore, in Hungary it is primarily on areas where the level of farming is so high that further increases in yield are mainly limited by the uneven distribution of rainfall with time that it is worth introducing irrigation.

In both irrigation development programmes irrigation systems were mostly established on areas with heavy soils where the loss due to leaching is not significant.

Irrigation experiments were carried out for 8 years on many different sites, and it was only in the case of mantle sands that nitrogen leaching could not be counterbalanced by a better conversion rate and more intensive nitrification. On meadow, alluvial meadow, solonetz meadow and lime-covered lowland chernozem soils smaller amounts of nitrogen fertilizer were needed under irrigated conditions to satisfy the nutrient demand of the same crop.

I have no experience on the conversion of phosphorus, potassium, and of meso- and microelements.

DEBRECZENI, B.: On the basis of results obtained in several years of experiments on the interaction between irrigation and fertilization, my answer is that with adequate irrigation techniques and the correct amount of water no leaching of nutrients (even of nitrogen fertilizers) occurs. At the same time the conversion of fertilizers, and thus the efficiency of fertilization, increases, and the nutrient availability becomes more favourable in irrigated soils. All this results in a lower specific fertilizer requirement for the planned crop compared to non-irrigated plants, which again may cause a further relative reduction in the potential leaching of nutrients.

HARASZTI, E.: The leaching of nitrogen fertilizers (or nutrients) as a consequence of incorrect irrigation is a source of considerable losses in intensive farming, particularly when there is abundant rainfall soon after irrigation. A favourable water regime in the soil, established by irrigation if necessary, is, however, a precondition for successful fertilization. The efficiency of irrigation farming can thus be ensured by a sensible compromise.

HARMATI, I.: The conversion of fertilizers and the nutrient-supplying capacity of the soil are considerably better on irrigated areas than under dry conditions, according to the results of our experiments. By keeping the soil permanently and properly moist more favourable conditions are provided for making the natural nutrient content of the soil available and for the uptake of the fertilizers ploughed into it. According to our investigations, the optimum nutrient level is lower under irrigated than under dry conditions, owing to the better conversion rate. In spite of the larger quantities of NPK extracted by higher yields, the soluble nutrient content of the soil did not drop compared to the unirrigated fields. This suggests a more intensive availability of nutrients under irrigated conditions.

Regular nutrient analyses on calcarous irrigated soils showed that no very great leaching of phosphorus occurred even when rice was grown; the movement of potassium was more significant. The PK level of the soil rose year by year as a consequence of fertilization. Nitrogen, on the other hand, was not found to accumulate to any considerable extent even in long-term experiments, which proves the escape and fixation of unused NH_3 and the leaching of NO_3.

When estimating the leaching of mutrients from the soil, the method of irrigation must also be taken into consideration. In rice production a larger amount of N and K leaching can obviously be expected than in the case of irrigation by sprinkling, owing to the great difference in the amount of irrigation water used each year. With sprinkler irrigation the annual amount of water is not more than 120—180 mm, which cannot cause very much leaching even in the case of nitrogen.

To sum up, the substantial leaching of nutrients need not be reckoned with under irrigated conditions (particularly with sprinkler irrigation).

HUSTI, M.: There is a close correlation between irrigation and the soil. Among the factors of soil formation irrigation has a prominent role. Under the influence of irrigation the earlier water regime of the soil undergoes a change, and as a consequence a new type of soil formation process begins. The earlier periodicity between aerobic and anaerobic conditions also changes. In some soil types this may even have an adverse effect on the soil structure. In such places the harmful effect should be eliminated by chemical amelioration or by the careful application of farmyard manure. The irrigation and fertilization system of the farm should be developed taking these factors into consideration.

I do not think that leaching will reach dangerous proportions if irrigation is carried out on the basis of soil analyses.

If on a given area the irrigation and fertilization plans are co-ordinated, irrigation will definitely promote thc conversion of fertilizers.

It is in the interests of the national economy for the different regions of the country to develop at approximately the same rate. It is therefore justified to create the possibility of irrigation on areas with poorer soils as well.

KISS, Á.: The extension of the irrigation areas is a world phenomenon, and one of the bases of surplus production. Wrong methods of irrigation, however, may result in a considerable extent of nutrient leaching. In this field irrigation experts possess reliable experimental data, so their advice should be followed by those carrying out irrigation in practice, if only to improve the conversion of fertilizers and reduce the extent of leaching to a minimum.

KOLTAY, Á.: Regular irrigation puts a strain on the structure of the soil, and badly executed irrigation may cause the leaching of nutrients. Provided proper irrigation techniques are strictly observed, however, these disadvantages can be reduced to a minimum.

By 1970 irrigation was carried out by sprinkling on more than 70% of the irrigation area in Hungary. When this technique is carried out properly it reduces the disadvantages mentioned above to an acceptable level. Under the climatic conditions of Hungary, which tend to be rather capricious, it is increasingly important to make up for the insufficient amount of precipitation and for the uneven distribution in time. I feel that if the production factors are properly co-ordinated the leaching of nutrients on irrigation areas could be prevented.

LŐRINCZ, J.: The irrigated area is, unfortunately, small, so it is not of much importance in determining the national yield averages. Within the farm, however, it presents the possibility of attaining very large yields and this must be exploited. If the yield is larger, then the active substance applied has certainly been utilized. The organic matter supply of irrigated areas is very important, since fixation to the organic matter reduces the extent of leaching as well. Irrigation is only one factor; the yield-forming factors must be considered together. In my opinion with appropriate cultural practices and varieties the extent of leaching is not likely to be dangerous. I think that the extent of utilization is greater than the damage caused by possible leaching. Great attention must, however, be paid to the danger of secondary alkalization.

MIHÁLYFALVY, I.: In irrigation trials on field crops grown on meadow and chernozem soils leaching was hardly observed, if at all, though it should be noted that the amount of water prescribed for one occasion was only enough to wet a 30 cm layer of soil. With a water norm of about 100 mm, which is capable of wetting a deeper layer of soil, the fertilizers might be washed out even in these soils, especially if the soil is cracked at the time of irrigation. According to the literary data, in sandy soils an unsuitable irrigation norm of 60 mm causes nutrient leaching.

NYÉKI, J.: The extension of the irrigated areas is a highly efficient way of increasing yields. However, its economic results can only be enjoyed if care is taken to apply the plant nutrients in optimum volumes and ratios, and, in contrast to present practice, grow high yielding varieties even under irrigated conditions. The nutrient supply of irrigated farms can only be successfully controlled by means of careful agrochemical analyses, as can the amount of irrigation water applied.

If all the above factors are duly co-ordinated, and nutrient application is adjusted to the larger yields expected, leaching need not be reckoned with, since under optimum water and nutrient conditions the plants take up the nutrients very quickly.

PAIS, I.: In my opinion, on properly irrigated areas the leaching of fertilizers is negligible. In fact irrigation, particularly sprinkler irrigation, should be carried out in such a way as to ensure at the same time the replacement of water soluble nutrients.

PECZNIK, J.; The interaction between irrigation and fertilization is a rather complex question. The physiological processes that determine the quantity and quality of yield (photosynthesis, respiration, transpiration, mineral nutrition*t* intermediary metabolism) also depend on the water and nutrient supply of the plantst which again are not independent of each other. It has already been mentioned that if the nutrient supply is favourable the transpiration coefficient of the plant is lower than when it is deficiently supplied with nutrients. It is also evident, that the nutrients from fertilizers and the soil are made better use of when the water content of the soil is optimum than under too dry or too moist conditions. The optimum fertilizer requirement of irrigated plants depends on the nutrition characteristics of the cultivated plant, the fertility of the soil, and the probable effect and interaction of irrigation and fertilization. The active agent required for the yield surplus envisaged in the case of irrigation is not always proportionate to the relative effect of irrigation; in fact it is usually lower than this, since irrigation increases the effectiveness of fertilization and mobilizes the soluble nutrient content of the soil. On irrigated areas, especially when irrigation is not carried out with due competence, the danger of fertilizer active agents being leached out will undoubtedly be greater. This applied primarily to nitrogen: in the groundwaters of irrigated areas a considerable increase in the nitrate ion concentration has been demonstrated in some cases. The extent of leaching naturally depends on the mechanical and chemical composition and the chemical reaction of the soil, on the position of the soil layers, the degree of slope, the depth of the groundwater, the amount of fertilizer used, the weather, the rate of irrigation, etc. When elaborating techniques for irrigated crop production all these factors, plus the need for environmental protection, must be taken into consideration, so as to prevent, or at least to reduce to a minimum, the leaching of nutrients. Low-action N-fertilizers could probably be used successfully in irrigation farming.

PETRASOVITS, I.: If irrigation farming is to show a steady profit intensive fertilization must be co-ordinated with the water supply.

If irrigation is properly applied fertilizer utilization is generally better, if for no other reason than the continuous and favourable availability of the nutritive substances. If the quality of irrigation is bad, i.e. the amounts of water used are larger than necessary, the intensity is higher than desirable or the distribution of the irrigation water is uneven, this has an unfavourable effect on fertilizer conversion.

The harmful consequences may be the leaching or washing away of micro- and macronutrients. Leaching, however, only occurs to a greater extent on sloping areas, and when irrigation is followed by a large amount (20 – 30 mm) or high intensity (40 mm/hour) of natural precipitation. In general, properly applied irrigation does not, in my opinion, result in significant leaching.

PLETSER, J.: In Hungary in most cases and on an overwhelming part of the country's territory the shortage of water limits the yields in agricultural production, and consequently the efficiency of fertilizers. On irrigated areas larger amounts of fertilizers can be used.

The amount of irrigation water is determined by the water consumption of the crop, which depends to a large extent on the weather. It is a mistake to think that more irrigation always means more yield. Excessive irrigation has often caused a yield depression compared to the non-irrigated areas. In such cases the losses are made even more serious by the cost of irrigation and the leaching of nutrients, which thus pollute the environment.

The Agrometeorological Department of the Central Institute for Atmospheric Physics has been giving advice on irrigation to the Transdanubian Regional Water Company for the last six years. Apart from regular meteorological and soil moisture surveys the evapotranspiration of irrigated crops is measured and phenological observations are carried out. The work of the advisory service is based on the actual water consumption of the plants and the changes in the water content of the soils. The upper layer of the soil, to a depth of 1 metre, is irrigated to 70 – 80% of its water capacity, so that even heavy rainfall cannot cause leaching. On areas irrigated by the Transdanubian Regional Water Company the water capacity of the upper one-metre layer of the soil is 300 – 400 mm. Thus, at 80% saturation the soil is able to absorb a further 60 – 80 mm rainwater and retain it against the gravitational force. Rainfalls heavier than that very seldom occur, and even then the water can be stored in the lower layer. Up to a depth of 2 m the saturation of the soil is about 60%.

It is clear from the above that with skilful irrigation checked by measurements no leaching of nutrients will occur.

POZSÁR, B.: Trickle irrigation gives the best results, and the extent of leaching is also the lowest with this method of irrigation. Any substantial increase in the yield averages of fodder crops compared to the rate of yield increase in wheat and maize can only be expected from irrigation.

SHMILLIÁR, M.: I think the first part of the question includes the answer; the farms must learn how to use the irrigation water properly. Unskilled irrigation will wash out the nutrients and will not increase the yield.

SZÉKESSY-HERMANN, V.—FAZEKAS, S.: The reduction of the damage caused by irrigation is connected in many respects with the question of damge occurring as a consequence of water erosion, so it would be worth considering the idea of combining artificial fertilization with the application of organic manure. Also, in connection with problems involved with both erosion and irrigation it seems to be worth taking another factor into consideration. As damage due to various degrees of slope is likely to occur on a considerable portion of the areas suitable for agricultural cultivation in Hungary, increased care should be taken in determining plot sizes. Would it not be useful, depending on the surface conditions of the soil, to break up the giant plots with belts of protective, soil-fixing vegetation and at the same time to give very careful consideration to the ecological characteristics of the crop to be grown there? These protective belts would obviously mean that a certain amount of surplus energy would be required for mechanized soil cultivation, but this would certainly be repaid by the reduction in the losses mentioned above. Finally, I should like to add to the arguments advanced in support of the establishment of protective belts the probable beneficial effect this would have on the regulation of the groundwater level, and the importance of such belts in providing a more favourable biosphere for our valuable small game stock.

TULCZ, I.: Special attention should be paid to the application of farmyard manure and artificial fertilizer on irrigated areas. When it is properly carried out irrigation does not cause sufficient leaching to affect its profitability. Nevertheless, on irrigated areas the nutrient level of the soil should be followed with attention by means of repeated soil analyses.

*

PÁL GY.: **The quality of sugar-beet is determined by the percentage sugar content and by the possible presence of substances which make the extraction of sugar difficult. Nitrogen fertilization has an adverse effect on both properties, however, it increases the yield to such an extent that sugar-beet cannot be economically grown without nitrogen fertilization. Do you think it is permissible, in the case of any crop, for the quality of the crop to become lower and thus for the production cost of the product made from it to become higher for the sake of the larger yields obtained by fertilization?**

ÁCS, A.: The relation between yield increase and quality deterioration is decisive both in sugar-beet and in other crops. If, for example, the volume of the crop increases by 30% and the sugar content is reduced by 2% (which is a considerable decrease) as a response to intensive nitrogen fertilization, then fertilization is economically justified from the point of view of both the national economy and the farm. But it is not economical for the sugar factory (more water has to be transported, a larger mass has to be processed, more energy is required per 1 kg sugar, etc.). From the point of view of the sugar factory this is a problem even if the sugar content is the basis of acceptance, unless acceptance on the basis of sugar content is carried out degressively. In this case the reduced delivery price may compensate for the loss. This is, in any case, a matter of calculation and analysis as to where the national economy optimum lies. Acceptance by sugar percentage also makes the producing farms consider the amount of nitrogen fertilizer to be applied.

BARACS, J.: Nitrogen fertilization undoubtedly has a great effect on the yield of sugar-beet, so much so that sugar-beet cannot be economically produced without it. Nevertheless, it is not right, in my opinion, to apply unreasonably large amounts of N-fertilizer simply in order to increase the yield, especially now that the delivery prices of sugar-beet have been adjusted to the sugar percentage. For example, starting this year the delivery price for beet with a 13% sugar content is 67.6 Ft/q, while for sugar-beet containing 17% sugar it is 88.4 Ft/q. If 350 q/ha sugar-beet is obtained using an optimum amount of fertilizer the sales returns may be as much as 30,940 Ft/ha, while a sugar-beet yield of 450 q/ha attained with an overapplication of nitrogen may only pay 30,420 Ft/ha.

In addition there will naturally be the transportation costs for an extra 100 wagons, so the cost of the surplus nitrogen fertilizer will certainly not be refunded; on the contrary, the profitability of the sugar-beet will be lower compared to the 350 q/ha yield average. If the question is considered from the point of view of the sugar factory, 1 q less sugar will be obtained from the larger volume of beet.

Bauer, F.: I think it permissible, in general, for the larger crops obtained as a result of fertilization to involve a certain degree of quality deterioration and a rise in the prime costs of the products produced from them. However, the extent of this can only be determined by economic calculations at national economy level, lest we lose on the swings what has been gained on the roundabouts.

Beke, F.: The adverse effect of nitrogen fertilization on the quality of yield can be kept within limits. The presence of free nitrate and nitrite ions above a certain level in plant products is undoubtedly more than disadvantageous, it is dangerous (in feeding, for example). Nitrogen fertilizer is only one of the yield-increasing factors in sugar-beet production. The large yield losses are caused by other faults in the production technology, and the large doses of nitrogen are mostly applied to conceal them. There are limits to how much nitrogen can be supplied.

Buzás, I.: Before answering this question I should like to clarify a few points.

Sugar-beet always contains substances which hinder the extraction and particularly the crystallization of sugar, which is the most important phase of the process. Some of the sugar is not crystallized, therefore, and passes into the molasses. Nitrogen compounds are perhaps the most dangerous of these substances, and therefore the best known ones. At the same time, sugar synthesis cannot take place without nitrogen-containing protein.

It is also extremely important to emphasize that there is no contradiction between large yield and good quality. As proved by the national statistical data and by the results of exact experiments, the quantity and quality of yield does not necessarily show a negative correlation in the case of sugar-beet either.

Thirdly, and this follows from the above, it cannot be regarded as a general rule that nitrogen fertilizer must always be supplied directly under the sugar-beet. The soil must contain sufficient nitrogen to satisfy the nitrogen demand of sugar-beet at an adequate quantitative and qualitative level of yield. If the soil in question is able to supply this amount of nitrogen, then nitrogen fertilization is not needed. In this case there is no sense in supplying the sugar-beet in advance with the amount of nitrogen expected to be taken up by the crop, when this amount may produce an excess of nitrogen which will not increase the yield but will cause a deterioration in quality.

Thus, it must be made clear what is to be understood by "large yield and good quality", what the nitrogen demand of this is, how the nitrogen-supplying capacity of the soil can be characterized, and finally, when the nitrogen demand and the nitrogen-supplying capacity of the soil are known, how the required amount of nitrogen fertilizer can be calcuated.

As I have already said, in the present economic situation of Hungary it is the maximum useful (extractable) sugar yield per ha that should be aimed at. Accordingly, if we wish to increase the extractable sugar yield per ha by means of nitrogen fertilization, that is, in a way which, unlike other methods (e.g. irrigation), increases the root yield at the expense of a reduction in the extractable sugar content of the beet, the quality of the sugar-beet can only be considered satisfactory as long as the increase in root yield is able to compensate for the deterioration in quality. This is equivalent to the maximum extractable sugar production per ha.

The nitrogen demand of the root yield associated with the maximum extractable sugar yield has been experimentally determined, and the nitrogen-supplying capacity of the soil can be characterized by measuring the nitrate content. If these two data are known the nitrogen fertilizer requirement can be calculated, which in the case of a high nitrogen level in the soil may in fact be zero.

Many farm data prove that on such soils 130–150 kg/ha nitrogen, a rate of fertilization recommended by many specialists, does not increase the root yield, but on the contrary may even cause a yield reduction.

Thus in some cases a certain degree of quality deterioration parallel to an increase in the amount of yield may be permissible, but this is not a general rule. In accordance with the details given above, an analysis of the actual national economic situation will decide whether with the given crop a large yield, good quality or (as in the case of sugar-beet) the maximum of some other parameter influenced by both the quantity and quality of the yield, should be the primary aim.

DEBRECZENI, B.: Maximum yield does not always mean the best quality. Moreover, it often happens that the qualitative characters of a large yield are unfavourable. Badly performed fertilization may, among other things, be responsible for this. From the point of view of plant nutrition another important question is how and to what extent the formation of the individual organic components of the plant can be influenced by a well-designed nutrient supply. The quantitative requirements with respect to the major compounds may determine the cultural practices and the method, date and rate of fertilization.

In most fertilization experiments today not only the quantity but also the quality of the crop is examined all over the world. Fertilizers may affect the chemical composition of the plants in various ways. We know from numerous plant analyses that, especially with high rates of fertilization, not only does the quantity of ions found in the fertilizer increase in the plant, but the ratio of other inorganic ions and organic compounds also changes

Many workers have observed that in general the usual rate of fertilization does not substantially influence the chemical composition of the plant. This requires an amount of fertilizer larger than that currently used in practice. Nevertheless, quite a number of literary references suggest that fertilization changes the direction and intensity of photosynthesis and metabolism in the plant, whereby the concentration of the most important organic compounds (proteins, carbohydrates, fats) and even that of the non-protein nitrogen compounds, vitamins, etc. also changes. Of the inorganic ions nitrite and nitrate may accumulate in the cells.

The sugar factories need sugar-beet crops with high and readily extractable sugar contents. The quality is determined by the saccharose content (digestion or polarization %), the invert sugar (mixture of glucose and fructose), the "harmful nitrogen" or "blue number" (which inhibits the crystallization of sugar) and the cond. ash content. In experiments carried out at Gödöllő between 1974 and 1977 NPK doses larger than 150 kg/ha were found to gradually reduce the sugar content of the beet and to increase the amounts of harmful organic and inorganic compounds; that is, the quality of the sugar-beet deteriorated. According to experience gained in Hungary and abroad it is primarily nitrogen fertilization that reduces the sugar content and the extraction percentage.

It is a good move to make the delivery price of sugar-beet dependent on the sugar content, as this may ensure the necessary harmony between yield increase, fertilization, production costs and quality.

GYŐRI, D.: Quality must not be allowed to deteriorate for the sake of larger yields. The conditions under which this deterioration can be reduced should be studied, and methods to prevent it must be elaborated. In my experience microelements also play a role in this. In short, harmonious mineral nutrition should be made standard and conditions under which the increasing yield does not involve a deterioration in quality must be ensured.

HARASZTI, E.: It is a well-known fact that although nitrogen fertilization increases the quantity of yield, it has an unfavourable effect on the quality of sugar-beet and on the extractability of sugar. In spite of this the nitrogen fertilization of sugar-beet is necessary even if this raises the production costs. The larger volume of food and feed that can be attained per unit area by nitrogen fertilization is needed to satisfy the increasing requirements of the world population. By means of complex fertilization and by working out how to use micronutrients correctly it is hoped that the deterioration of quality can be reduced to a minimum.

HARMATI, I.: According to the results obtained so far, when fertilization is properly carried out it improves the quality of the crop in addition to increasing the yield. This result was found for cereals, maize, alfalfa and grasses. Sugar-beet is an exception in this respect. A deterioration in the quality of yield was only caused by excessive fertilization, especially by an over-application of nitrogen.

KISS, A. S.: A high rate of nitrogen fertilization, particularly if it is one-sided, often has an adverse effect on quality; however, this effect can be reduced, or even eliminated by the simultaneous application of other nutritive elements, as we found when adding magnesium as a supplement in nitrogen fertilization. Even if the quality of the crop is poorer, for example, because of the reduced sugar content, the sugar output per ha will still be higher due to the larger total yield. This seems to me to be permissible in spite of the somewhat higher production costs, as it contributes to a better food supply (larger volume of end-product).

KISS, Á.: Until quality is reflected in the delivery price, producers will concentrate on high productivity, which is attained by excessive nitrogen fertilization. Correct views on fertilization can only be developed by co-ordinated production management and a reconciliation of the interests of producers and users.

KOVÁTS, A.: Besides an increase in the quantity of yield emphasis should also be laid on the quality. This applies not only to sugar-beet but to other crops too. The quality should be controlled by the delivery price of the produce, which should be designed to encourage efforts to improve the quality. It is in the interests of the farm to obtain the highest income per unit area. This is influenced not only by the size of the yield but also by a price policy which remunerates quality. A compromise must be made between the two. At a low level of production concessions should be made in favour of the quantity. If the level of production is high enough, then the question of quality comes into prominence.

LÁNG, G.: It is an old problem in sugar-beet production to decide what concessions can be made with respect to the sugar concentration of the beet in order to increase the yield of sugar per unit area. Considering the average transportation distance from field to factory, and the present costs of sugar production a decrease of concentration of up to 15—16% does not cause any considerable problem.

LŐRINCZ, J.: This problem must be settled on a nation-wide basis. As long as crops are paid for by quantity, quality will be pushed into the background. If the amount of fertilizers applied is to be reduced, new varieties will be required, otherwise the index of economic efficiency will only be acceptable with larger yields. An objective method of acceptance on the basis of quality would have a great regulatory role. But this must be manifest in the prices as well (for sugar-beet, wheat, maize, alfalfa, etc.). A decision in this matter can only be made taking the interests of the farms and industry into consideration.

MIHÁLYFALVY, I.: Our experiments and investigations revealed that abundant nitrogen applied to sugar-beet caused a significant increase in root yield and in the harmful nitrogen content of the beet itself. The abundant nitrogen fertilization decreased the sugar extraction more than it increased the yield. By applying a correct NPK ratio (1.0 : 0.8 : 1.0) the harmful effect of nitrogen can be eliminated.

According to recent examinations performed in apple plantations the over-application of potassium reduced the storability of the fruit, as potassium antagonizes the incorporation of calcium, an element indispensable for firm tissue texture.

MOLNÁR, J.: Under the influence of intensive cultivation the yield averages have greatly increased, which cannot be said of the value of the components. In my opinion this is a necessary concomitant of intensification which can only be lessened but not eliminated even with the greatest competence and the use of the most suitable varieties.

Not only the costs of industrial processing but also those of agricultural production have increased as a result of the above. The area demand of the unit product (end-product) must also be taken into consideration (e.g. sugar or meat). Hungary has not sufficient arable area to produce industrial raw materials or fodder crops with much lower yields but with a somewhat higher value of components.

The deviation from the classical value of the components in a negative direction is experienced by the farms too, chiefly through fodder analyses (e.g. maize starch equivalent).

Unfortunately, it is characteristic of some feeds, that compounds toxic to animals are formed in them (e.g. aflatoxin, Fusarium toxin in maize). This is also a consequence of the increased susceptibility of high yielding maize varieties to pathogens.

NYÉKI, J.: Unfortunately the relation between quality and quantity has been the subject of discussion for a very long time. Until the environmental factors reach an optimum the quality definitely improves, but as soon as we go beyond this limit a negative correlation is to be expected.

The correlations should be considered specifically, for individual crops or groups of crops.

The anxiety expressed in the question is particularly justified in the case of sugar-beet; with cereals the danger is not so great. The processing of sugar-beet and the storage of potato and fruit are definitely less favourable after an excessive application of nitrogen. With a correct price policy and regular quality control the difficulties can be eliminated, and the tendency desired at the level of the national economy will be set up automatically.

PAIS, I.: It is indisputable that the required quantity, and to a certain extent quality, of yield cannot be achieved without nitrogen fertilization. Fertilization must not, however, be applied at the expense of the value of the components; in this case the volume of yield should be a secondary factor. To use sugar-beet as a model: processing a larger amount of raw material with a lower sugar content consumes much more energy, and consequently costs much more, than when a smaller quantity of better quality sugar-beet is grown by the farms. The crop should therefore be graded by quality rather than by quantity.

PECZNIK, J.: The harmful consequences of excessive nitrogen fertilization have already been mentioned. An adequate nitrogen level in the soil is one of the most important preconditions for attaining large yields, while an overapplication of nitrogen may have an adverse effect on the quality of certain crops. In 1976 the sugar content of the sugar-beet crop was extremely low in Hungary, but apart from fertilization the varieties grown and the weather were also responsible to a considerable extent. The following year the sugar content of the sugar-beet was substantially better.

Considering that in a socialist country no antagonism can be allowed to arise between the raw material producer and the processing unit, some conciliation of the different interests must be achieved, among other things by setting a delivery price which gives suitable recompense for crop quality. This is, in fact, to be expected in the near future. Naturally, the problem is really more complex than this: most plants are not produced for their own sake, but for fodder or food. The ultimate criterion is the direct or indirect nutritive value of the crop, or of the product produced from it, from the point of view of human biology. Unfortunately, the relevant analyses are still at the initial stage, and for the time being attention is only paid to conspicuously unfavourable phenomena (deficiency diseases in animals, methaemoglobinaemia caused by the high nitrate-nitrite content of drinking water, etc.).

PETRASOVITS, I.: In the case of crops produced for direct human consumption fertilization must not in general be aimed at obtaining larger yields at the expense of quality. With crops produced for industrial purposes, on the other hand, this is often permissible if the poorer quality is compensated by a yield surplus, and does not render the processing technology too expensive.

In the case of fodder production the feed value yield per unit area (quantity, quality, digestibility) rather than the total volume of crop is the decisive factor.

POSGAY, E.: Nitrogen fertilization decreases the amount and the extractability of sugar contained in the sugar-beet, but at the same time it increases the volume of root yield.

The deterioration in quality caused by a higher rate of nitrogen fertilization is initially only slight, but it shows a gradually increasing tendency.

The situation is the opposite in the case of root yield; the initial intensive growth later slows down.

This points to the fact that there is a nitrogen level above which the extractable amount of sugar is reduced in an absolute sense. If the nitrogen supply exceeds this level it is definitely uneconomical.

The question of the extent to which it is practicable to make use of the yield increasing effect of nitrogen application within the range where the amount of sugar extracted still continues to rise is not the concern of fertilization or agrotechnical experts and will be discussed later.

"Sugar-beet cannot be grown without nitrogen fertilization", it says in the question. In Hungary this is certainly so, because there is no sugar-beet area which was not given nitrogen fertilization this year or, at the latest, last year.

At a certain level continuous, regular fertilization considerably increases the fertility of the soil, and this effect is felt even when the nitrogen has not been supplied directly to the sugar-beet. In this sense it can be said that sugar-beet can be grown without immediate fertilizer application, and if fertilization in the previous years is deliberately carried out to this end, then this could well be the best method of sugar-beet production.

To return to the basic question, that is, the extent to which it is practicable to make use of the yield-increasing effect of nitrogen fertilization, this is decided at the level of the national economy. If, taking the world market situation into consideration, it is economical, then even a maximum exploitation of the action of nitrogen on the amount of sugar is justified, since in the case of sugar manufacturing only the production costs will increase; the end-product, sugar, can be produced in the same quality irrespective of the extraction percentage. And here a distinction must be made between sugar and those crops in which nitrogen causes unfavourable changes in the quality.

The optimum nitrogen supply in a given case may depend, for example, on the processing capacity of the sugar industry as well. The lower the capacity, in other words, the longer the peak processing period, the more important it is to produce a unit amount of sugar from as small a quantity of sugar-beet as possible, that is, the sugar-beet should contain a higher percentage of extractable sugar, because the storage losses will decrease with the shortening and increase with the prolongation of the peak period and this may considerably affect the efficiency of the whole vertical system.

Even the correlations outlined above show that the term "optimum" depends on a great many factors. Nevertheless, it can safely be said that in the case of sugar-beet the poorer crop quality caused by applying larger amounts of nitrogen to obtain higher yields, and the higher prime costs of the product thus obtained are permissible, though the latter is not a necessary consequence of the former.

POZSÁR, B.: The sugar industry should buy up sugar-beet on the basis of its saccharose content, and this undoubtedly has an influence on production technology, including artificial fertilization. However, it should be remembered that a relative shortage of nitrogen tends to check growth, which may be a critical and limiting hindrance to dry matter accumulation.

SEMJÉN, I.: The nitrogen fertilization of sugar-beet has recently been the subject of nation-wide discussions. With the modern requirements and under the present conditions an adequate yield is inconceivable without nitrogen application. Sufficient nutrient cannot be provided by farmyard manure, not to mention the favourable effect of the latter on weed growth, which means that it is not willingly used by the farms. The rate of nitrogen fertilization both for sugar-beet and other crops can be raised up to the point where the yield can only be increased further at the expense of quality. The opinion formed in many cases after the 1975 crop year, namely, that the very poor digestion of sugar-beet (10—12%) was exclusively due to the use of nitrogen, cannot be accepted. That this was not so was proved very clearly by the years 1976 and 1977.

Let us examine the year 1975 from this point of view. The digestion of sugar-beet on a national scale was 10—12%. (With the obsolete and outworn machinery, which has been in use for half a century, 2—3% less sugar could be obtained in the course of manufacturing.) The loss was thus partly caused by the out-of-date equipment, as proved by the fact that 2—3% more sugar was extracted from the sugar-beet transported to Yugoslavia for processing than from that processed in Hungary.

Those who oppose the use of nitrogen leave out of consideration the fact that growth seasons with as little sunshine as 1975 have not occurred for 100 years, though this is the most decisive of all the factors determining the yield. They also ingnored the fact that a quality deterioartion was observed in other crops at the same time. The fruit was tasteless, the grain had low baking quality, and the grapes contained very little sugar (8—15%) that year. Some people thought this was all of minor importance and put the blame on nitrogen alone.

In 1976 the production factors were very different. The weed problem was solved, the Cercospora control was successful, the number of sunshine hours was higher, the agrotechnical conditions were better, and the capacity of the processing industry was improved.

The amount of nitrogen applied on our farm increased from 200 to 240 kg/ha. The digestion of sugar-beet reached 14—16%. In the 1977 cropyear, under similar conditions, with a 300 kg/ha rate of nitrogen fertilization, the digestion was 15—17%.

On a production area of 200 ha at the Sárszentágota Cooperative Farm the average yields in 1975, 1976 and 1977 were 460, 445 and 455 q/ha, respectively.

All in all, it is not artificial fertilization or the use of nitrogen that reduces the quality. Today high level production of a suitable quality and quantity is inconceivable without a co-ordinated, harmonious and economical use of fertilizers.

It is not the farmers' job to decide to what extent the accumulation of nitrate, a component which influences the manufacturing process and is harmful to human health, should be allowed.

The authorities in charge of production can influence the quality and quantity of production through the price system by means of incentives and regulators according to the interests of the public and of the national economy. The farms will no doubt follow the directives.

Shmilliár, M.: An excessive rate of nitrogen fertilization is one of the factors that unfavourably influence the quality of sugar-beet. Similarly adverse effects are exercised by diseases caused by yellow virus and cercospore infections. Healthy sugar-beet is highly responsive to large amounts of fertilizer.

Experiments carried out at Szarvas between 1973 and 1976 by Dr. Posgay showed that under irrigated conditions a high rate of fertilization increased the root yield of sugar-beet (1.2 ton/ha), but the sugar output was the highest in the case of a medium rate of fertilization (0.6 ton/ha).

Furthermore, these experiments confirmed that the quality of sugar-beet and the quantity of sugar produced were decisively influenced by the number of plants per unit area. Under dry conditions the plant number was 110,000/ha, while in the case of irrigation farming it was 148,000/ha. In large-scale farms the plant number is mostly less than fifty per cent of that in the experiments, so the deterioration in quality is greater.

The deterioration in quality is not usually compensated for by the larger amount of yield. The poor quality of industrial raw materials or fodder cannot be made up for by large quantities, the latter only increases the production costs, which cannot be tolerated beyond a certain level. In the case of fodder crops, the capacity of the animal organism is limited, and if it is filled up with bad quality feed not only is it impossible to produce a surplus, but the production may even decline. But where is the limit to which nitrogen application can be increased? Under Hungarian conditions, apart from some exceptional cases, we do not use as much nitrogen fertilizer yet as could be safely used. It would be desirable to produce types of nitrogen fertilizer which act more slowly. Again, I should like to emphasis the quality of the product rather than the economic efficiency. There are crops in which bad quality causes incalculable damages and where the crop may even become useless.

Szalay, S.: It can be seen not only in sugar-beet production but unfortunately also in the case of a great many other crops that the quantitative increase produced by a high rate of fertilization is achieved partly at the expense of quality (e.g. spots and rotting in intensively grown apples due to physiological disorders; tuber crops "blown up" by an excessive nitrogen supply, or "lush green" fodders poor in mineral substances, etc.). It has not been scientifically proved as yet in many cases whether or not the disadvantages connected with the otherwise advantageous large yields are the consequences of a relative microelement deficiency. Liebig's minimum rule applies to micronutrients as well. The microelements are generally less mobile and more difficult to absorb than nitrogen fertilizers. It is known, for example, that dry heart-rot, the inner cavity found in overfertilized tuber crops, is caused by a relative boron deficiency. I think that a great deal of scientific research is still needed, but once we have learned more we shall be able to ensure unobjectionable quality combined with a large yield. Perhaps this will be the next great victory of chemization in agriculture.

Szeniczey, Cs.: An overwhelming proportion of plant products are subjected to processing before they are used. The acceptance of products according to quality is slowly becoming general practice (sugar-beet, wheat, etc.).

It is an exclusively economic question to what extent the yield should be increased at the expense of quality. The requirements with regard to the composition of vegetable products directly used in livestock farming are determined solely by the purpose to which they will be put. In this case a quantitative view of plant production is definitely harmful (see the impact of starch, protein, trace element deficiencies, etc. on livestock farming).

SZÉKESSY-HERMANN, V.—FAZEKAS, S.: An increasing number of data confirm that excessive fertilization makes certain plants accumulate larger amounts of nitrogen-containing compounds. These compounds may be harmful to the plant itself, and may exert a harmful effect on the health of the man or animals consuming them (e.g. the accumulation of nitrate and nitrite in vegetables). In our opinion, considering our present living standards, it is not the prime cost of sugar (sucrose) production that should settle the problem raised in connection with sugar-beet production. Much more important, assuming of course that the extracted sucrose is free of contamination in this sense of the word, is the question of whether the by-product to be used for feeding contains substances harmful to animals, and indirectly to man as a consequence of nitrogen fertilization.

TARJÁN, R.: The question of whether to produce a poorer quality crop at higher costs for the sake of attaining a larger yield must be considered separately in each case with an exact knowledge of the extent of quality deterioration.

TULCZ, I.: Controversies about the fertilization of sugar-beet generally exaggerate the effect of nitrogen on the sugar content. In our co-operative farm there was a significant difference over the last two years in the sugar content of the beet despite the fact that the rate of nitrogen fertilization was the same, so the explanation must be found in other factors, chiefly in the weather.

In my opinion the rate of fertilization, particularly that of nitrogen fertilization, should be increased as long as it still produces a higher absolute value. Continuing to take sugar-beet as our example, it is quite clear, for example, that a 500 q/ha yield of sugar-beet containing 13% sugar is more desirable than 300 q/ha with a 15% sugar content.

*

PÁL, GY.: **Besides the advantage of being easy to handle and move (pumping) liquid fertilizers require an appropriate storage and distribution network as well as transporting capacity, and at the same time up-to-date machinery has to be made available for applying them to the soil. if the costs per unit nutrient can be made substantially lower than those of solid fertilizers, do you think liquid fertilizers will gain ground in Hungarian agriculture in spite of the above-mentioned difficulties?**

ÁCS, A.: I am of the opinion that it will be difficult to fulfil the technical conditions required for liquid fertilizer application, and I do not believe that the cost of liquid fertilizer per unit nutritive value will be substantially lower, either. I therefore have doubts about the rapid spreading of large-scale liquid fertilizer application.

BARACS, J.: If the conditions of storage, delivery and distribution are satisfactory liquid fertilizers will definitely be used in the future on farms with adequate levels of production.

The cost of establishing liquid fertilizer stores is basically the same as that of building stores for solid fertilizers; transportation and storage can be solved with virtually no loss. Distribution can be carried out very well with the currently available machine types Kertitox I/M and Kertitox I, which are supplied with subsoilers, injectors and foam indicators.

Agriculture, however, is unable to bear the costs of delivery (in wagons or tankers) from the factory to the site of utilization or to the farm stores. So for the time being liquid fertilizers can only be used in farms situated near the factories. As far as the city of Pécs is concerned, one solution might be the transportation of liquid fertilizer in the railway tank wagons which will be unnecessary for gas oil and petrol after the establishment of the Százhalombatta—Pécs pipeline system.

BAUER, F.: Apart from the fact that the unit amount of nutrient introduced in the soil with liquid fertilizers will be substantially cheaper than in the case of solid fertilizers, if liquid fertilizers are to be generally used the investment costs of storage and distribution facilities and machinery should be divided between industry and agriculture.

BEKE, F.: The price of liquid fertilizer (mainly NH_4) may be 1/3 lower. I have no data as to the prices and qualities of other fertilizers.

Transportation, storage, distribution and health protection would require enormous investments in the near future if liquid fertilizers are to be introduced. With traditional fertilizers these factors do not present such a problem.

The greatest problems arise with the machines required for liquid fertilizer distribution. The different working widths of the distributors, the decreased performance, the increased danger of breakdowns owing to the diversity of the mechanism and the increased demand for tractor capacity are all factors to be taken into consideration. In addition, some of the usual machine should be kept for the distribution of other types of fertilizers.

I think that the introduction of this method of fertilization will take time, and only the most profitable farms will be able to start it.

Calculations would be needed, taking into consideration the prices and the positive and negative factors, to determine whether the advantage would be felt by the national economy or at farm level.

BEKE, I.: Liquid fertilizers are likely to be widely used once the necessary technical and human conditions are provided.

The use of liquid fertilizers has many advantages compared to solid fertilizers. The greatest advantage is the uniformity of distribution which can be best attained in this form.

Once the necessary conditions exist a rapid spread of the method can be reckoned with.

BUZÁS, I.: In my opinion it is quite certain that liquid fertilization will be introduced in Hungary, at least to the extent to which it has been introduced in capitalist countries with developed agricultures, or in some socialist countries.

DEBRECZENI, B.: It is realistic to expect the use of liquid, pressure-free UAN-nitrogen solutions, NP and NPK solutions, and particularly suspensions to gain ground in Hungary. This is encouraged by the bad quality and uneven grain size of the current solid simple fertilizers, and the consequent lack of a satisfactory mixing technology. The more even distribution pattern of liquid fertilizers and the possibility of combining them with plant protection and irrigation operations give them a considerable advantage. However, it is only realistic to expect liquid fertilizers to be used to cover fertilizer requirements exceeding the present solid fertilizer production capacity.

GYŐRI, D.: Liquid fertilizers have the advantage that they can be distributed much more evenly than solid fertilizers. In addition their active agents are in solution, so they can reach the roots of the plants and be absorbed by them more rapidly. It is therefore likely that they will be widely used in the future, though the achievement of a higher technical level in the farms is an important precondition.

HARASZTI, E.: At an appropriate technical level the effect of liquid and solid fertilizers on yield and economic efficiency are nearly the same. The wide application of liquid nitrogen fertilizers in Hungary will be greatly influenced by the costs of the facilities required for transportation and distribution. A great disadvantage is that with this method the introduction of complex fertilizers into the soil is expensive, if it can be achieved at all. The results of the experiments carried out so far in Borsod County (Hungary) are not, in my opinion, sufficient to settle the question.

HARMATI, I.: Due to the great advantages involved, the introduction of liquid fertilizers can definitely be expected provided they become available at reasonable prices, and provided the proportion of the investment costs charged to agriculture is not too high.

It is to be hoped that the technological difficulties encountered in the use of solid fertilizers will encourage the production of liquid fertilizers. The application of the latter requires less manual labour. The marketing, transportation and mixing of liquid fertilizers can be fully mechanized. They are homogeneous, and easy to mix and dilute. The amount and ratio of active ingredients they contain can be adjusted easily and precisely. They can be uniformly distributed and their distribution can be combined with plant protection operations. Their action is equivalent to that of solid fertilizers. In spite of these outstanding advantages the high investments they require will probably postpone their introduction.

HELMECZI, B.: Personally I should be very glad if the conditions necessary for the introduction of liquid fertilizers were provided, particularly as this would also solve the problem of the agricultural utilization of liquid manure and communal sewage, which is considered superfluous by some, and dangerous by others, who also think it causes environmental pollution.

KISS, A. S.: An even distribution is one of the preconditions of proper fertilizer utilization. With the present solid fertilizers a 20—30% irregularity of distribution is regarded as satisfactory, but it is sometimes as much as 80—100%. Uneven distribution may result in a 10—30% loss of yield. An even distribution is easily ensured with liquid fertilizers, so their application is likely to be widely introduced in spite of the difficulties of transportation and storage. Since today, using various salt combinations, active agent concentrations as high as 30—50% can be attained, earlier complaints of how expensive it was to "transport water" are no longer valid, as the liquid is more concentrated than the present solid fertilizers. In the case of NPK solutions the problem lies in the fact that they can only be used in the form of a suspension. A suspension is liable to sedimentation and ageing even when additives are used. It is therefore probable that only true solutions will be storable, while substances (e.g. potassium) that produce a suspension will be mixed immediately before use. For the time being storage appears to raise more problems than in the case of solid fertilizers; the use of earth cisterns lined with sheets of polythene seems to be promising. The price of liquid fertilizers (calculated for active agent) must be lower than that of solid fertilizers (where there are no distillation costs). Since liquid fertilizer is not only cheaper but also easier to handle (mechanize), it can be regarded as really up-to-date, and will, in my opinion, be widely introduced, though it is unlikely to fully replace solid fertilizers.

KISS, Á.: The use of liquid fertilizers will gain ground in agricultural production in Hungary as elsewhere, once industry has solved the problem of mechanizing economical distribution.

KOLTAY, Á.: In Hungary solid fertilizers are still used almost exclusively. However, since liquid fertilizers are cheaper, and are easier to mechanize than solid fertilizers, they are gaining ground all over the world. They are likely to be introduced in Hungary too, if the production costs of liquid ammonia and aqueous ammoniacal solution are really only half the production costs of solid nitrogen fertilizers.

The spread of liquid fertilizers is hindered by the fact that their storage, delivery and distribution require highly expensive special equipment. I think that if the cost of liquid fertilizers per unit nutrient were considerably lower than that of solid fertilizers they would quickly become popular.

KOVÁTS, A.: The introduction of liquid fertilizers requires a well organized supply and application chain which is technically and professionally well-equipped. This requires considerable financial and material resources. Consequently liquid fertilization is not used nearly as widely anywhere in the world as one might think from the literature which deals with it. In France, for example, only 10—15% of the nitrogen is applied in a liquid state. In Hungary this method of fertilization is still at the investigatory stage. The use of liquid fertilizers is expected to be introduced first in the vicinity of the fertilizer factories, but a consumption higher than 10—15% (on an active agent basis) cannot be except for the next ten years.

LÁNG, G.: Of all the liquid fertilizers ammonium nitrate carbamide, the agrotechnical advantages of which have already been mentioned, is likely to be the first to be introduced. The saving on the rather high costs of sacking also advocates the use of liquid nitrogen fertilizers. A further reason is that the handling of sacked fertilizers required a great deal of manpower, which is also unnecessary for liquid fertilizers.

LŐRINCZ, J.: This question is very complex. It is not enough to solve the problems of transport, storage and distribution; the preparation of the soil will also be more expensive. Who will pay the costs of the extra investments? For the time being good quality, better composition (active agent ratio) and, above all, well granulated fertilizers are badly needed, and machines suitable for distributing them.

Liquid fertilization, which is expected to be a reality by the end of the century, will represent a new period in agricultural production. Beyond the economic questions the problems of complex liquid fertilizer manufacturing must also be solved.

MIHÁLYFALVY, I.: Provided the problems of storage, transportation and distribution into the soil are solved, and technological discipline is strengthened, the wide introduction of liquid artificial fertilizer utilization should be possible. The question is, however, to what extent industry will undertake to support these investments, and what the size of the cost per unit nutrient will be. For the time being any statement concerning the wide application of liquid artificial fertilizers would be premature.

It should be mentioned here that in the German Democratic Republic, where there is a high level of technological discipline, the use of liquid artificial fertilizers is nevertheless not expending to the "desired" extent.

MOLNÁR, J.: Liquid fertilizers could be distributed with an accuracy which is impossible with solid fertilizers.

The application of liquid fertilizers demands the development of a special infrastructure which will not be cheap. When agrochemical centres are established this possibility should be taken into account.

NYÉKI, J.: In my opinion the wide use of liquid fertilizers will be promoted by the advantages of its agricultural application rather than by the production costs.

Of these advantages the possible saving of manual labour, which is more and more difficult to obtain, must be mentioned in the first place.

The efficiency of liquid fertilizers, assuming that it is equal to that of solid fertilizers, can be explained by the fact that the ratio of macroelements can be better adjusted to the soils and crops of the given farm, and uniform distribution is easier to attain.

I do not expect the price of liquid fertilizers to be lower, as the whole Hungarian fertilizer industry is designed to produce solid fertilizers. The amortination of an investment costing many millions of forints will be added to the production costs of liquid fertilizers even if the manufacturing process is apparently cheaper.

However, the development tendency is clear for the reasons outlined above. The financial burdens (extra investments by farms, amortization of industrial units) cannot be imposed on one branch or other of the national economy, but must be shouldered jointly, in which case the use of liquid fertilizers is likely to be introduced into agricultural practice very soon.

PAIS, I.: Sooner or later the introduction and wide application of liquid and dissolved fertilizers will be an established practice. This will require a considerable amount of investment and organization, but in future the tendency will definitely be to use nutrients in a dissolved state. This way of supplying the plants with nutrients is simpler, more efficient and easier to mechanize.

PECZNIK, J.: As the production and utilization of fertilizers increases, the storage, trade and distribution of the ever increasing volume of fertilizer (some 6.2 million tons by 1985) cause more and more problems which require up-to-date solutions. Instead of the expensive and labour-intensive method of packaging the fertilizers in bags, which makes it difficult to introduce up-to-date handling methods, a system of fertilizer storage must be found which can be automated. The application of large amounts of fertilizers makes it necessary to use high capacity machines capable of satisfactorily even distribution. These requirements can be fulfilled by using liquid fertilizers and suspensions.

The advantages involved in introducing liquid fertilizers are first and foremost of an economic nature. In manufacturing liquid fertilizer less raw material and fewer work processes are needed to produce the fertilizer, which means that the costs of investment and production are also reduced. Marketing, transportation and handling can be fully mechanized. Agriculture can also make the best use of scientific results and technological achievements by using a fertilizer of high physiological value, which can be evenly distributed and localized, which can be combined with a wide range of agrotechnical and chemotechnical operations, and whose active agent ratio can be adjusted to the current local demands (of crops and plots).

The shortage of manual labour in Hungary, as in the rest of the world, means that the development of procedures which are easy to mechanize is imperative.

In the simple and complex liquid fertilizers of solution and suspension type all the nutritive elements are present as water soluble compounds, in forms readily available and fully utilizable by the plant. The primary nutritive elements (particularly nitrogen and phosphorus) are present as ion groups with different valencies which makes the nutrient supply both quick and continuous.

Since the active agent ratio can be adjusted according to the nutritional and physiological requirements of the plant and also to conform with the aims of the cultural practices employed, they are extremely efficient, multi-purpose fertilizers.

Our own laboratory, pot and outdoor experiments, carried out since 1971, prove that simple and complex liquid fertilizers of the solution type, with carbamide-ammonium-nitrate or ammonium-polyphosphate bases, applied by themselves, in combination with microelements or herbicides, or together with irrigation water, are nutrient sources at least equal to the modern solid fertilizers agrochemically, and in some respects even superior to them.

Liquid fertilization can be adapted extremely well to the soil conservation and plant protection technologies of the large-scale crop production systems.

In Hungary it is already possible for certain nitrogen fertilizers (carbamide, ammonium nitrate) to be delivered to the user in the form of a solution. Such problems as the hygroscopy and cementing of the fertilizers, which now cause serious problems, do not arise at all with the nitrogen solutions.

When establishing liquid fertilizer factories the agrochemical centres should be regarded as part of the vertical manufacturing system. The fertilizer factories should produce the basic components (N solutions, NP and NPK solutions), from which the mixing units at the agrochemical centres, using the so-called cold mixing technique, would then make up fertilizer solutions, or possibly suspensions, the compositions of which would meet the demands of the users.

Certain technical conditions are required for the application of liquid fertilizers. It looks as though a large proportion of the equipment and machinery required for the introduction of the technology will be available from domestic sources. Thus, Hungarian products such as steel or plastic containers, and plastic or rubber covers for the storage of liquid fertilizers and for the transporting and distributing tanks can be used, provided the special requirements (e.g. corrosion protection) are taken into consideration. The modern low-pressure Hungarian-made sprayers can also be used with minor modifications for the distribution of liquid fertilizers. It will be possible to construct liquid fertilizer adapters to be mounted on seed-drills, and the complementary fittings which will be necessary for irrigation systems can also be supplied totally or in part by Hungarian industry.

Liquid fertilizers will be very useful to the farmers, so they can be expected to be widely used. This means that preparations must be made as soon as possible for their storage and handling. First of all N solutions are likely to be introduced, followed later by complex NP fertilizer solutions manufactured in Hungary or in one of the socialist countries.

PETRASOVITS, I.: The future of liquid fertilizer utilization in Hungarian agriculture is not determined primarily by the ecological and technical solutions and conditions. These are very promising, in spite of the difficulties.

The relatively rapid and wide introduction of liquid fertilizer in Hungarian agriculture depends on subjective conditions. The better the organization and professional level of production, transportation, storage and application, and the more efficient the agricultural production and technological discipline that integrates all these, the quicker they will gain ground.

POZSÁR, B.: NPK fertilizer suspensions with various compositions have already appeared in Hungarian agriculture. In spite of the difficulties, liquid fertilizer is the thing of the future. Althogh the investment costs of ammonia distribution are the highest of all, the active agent content is also the highest with this method of fertilization.

RAKONCZAY, Z.: I do not wish to give an opinion on whether, in spite of the storage difficulties, liquid fertilizers will gain ground in agriculture provided the costs per unit nutrient are substantially lowered compared to those for solid fertilizers. But I do wish to state that before liquid fertilizers are introduced some solution must definitely be found for the utilization of liquid farmyard manure, both for economic and environmental protection reasons.

It is well known that concentrated livestock farms produce large quantities of liquid manure. It is also known, that the consequent investments required for the protection of the environment may increase the expenses by 30–40%. Both from an economic and an environmental protection point of view it would be far better to utilize the liquid manure for the fertilization of agricultural areas, instead of making such expensive investments.

Shmilliár, M.: I think that one or two model farms should be marked out now for the introduction of liquid fertilization. In farms equipped with irrigation facilities this could be solved with relatively small investments. Experience obtained in this field would be of great value and would provide grounds for further decisions. Transportation through pipelines is one of the most economical solutions; by means of makeshift pipelines concentrated solutions could perhaps be delivered to the tanks of the users, from where they would be carried to the field through permanent pipelines.

Szeniczey, Cs.: The well known disadvantages of solid fertilizer utilization (transportation alla rinfusa, problems of quality, storage, uneven distribution, low number of active agent combinations, etc.) have just about reached the limits of tolerance of the farms.

The storage, delivery, distribution and homogenization of liquid fertilizers, and the variation of their active agent contents are, paradoxically, easier than in the case of solid active agents.

Jobs which could only be done manually up till now can easily be mechanized for liquid fertilizers (suspensions).

This technological solution is the only possible way of taking a step forward, even if it is more expensive than the traditional one.

A liquid fertilizer storing and distributing system capable of covering the whole county of Komárom is now being constructed.

Székessy-Hermann, V.—Fazekas, S.: While planning the development of agriculture in Hungary we must not forget that the area of the country is small. Besides the highly expensive development of fertilization more attention should be paid to the exploitation of the possibility offered by the fact that livestock farming and crop production take place in Hungary side by side, restricted to a relatively small area. There is thus plenty of opportunity for an economical joint application of organic manure and fertilizers, and in general, for the co-ordination of the technologies applied. The efficiency of a country's agriculture based on the strengthening of the industrial background can only be judged correctly after a longer period. Highly developed countries with large agricultural areas are also faced with difficulties in this respect as shown by the leading article of a recently published copy of Science (vol. 199, No. 4327, 1978), according to which, in contrast to the rapid and economical increase in yields from the end of World War II until 1970, agriculture has recently shown a stagnation. The article also calls attention to the danger of a yield depression in the near future owing to the depletion of the biological reserves of the land, the diminishing of the topsoil, etc. The article goes on to enumerate the new lines of research which seem likely to promote development; it is not surprising that these are mostly of a biological character. As for as Hungarian conditions are concerned, it should be emphasized once again that despite its small territory the country possesses good agricultural conditions but the possibilities of utilizing new areas for this purpose are very limited. In our development plans it would hardly be wise to ignore the fact that the possibly short-lived technologies from countries with substantially greater possibilities can only be adopted after a thorough evaluation. We must always keep in mind that it is not admissible, for the sake of a temporary increase in efficiency, to take the risk of going beyond the limits of nature's regenerating ability in our transformation of the environment and then being compelled to spend the bulk of our energy on restoration.

Tarján, R.: The application of liquid fertilizers undoubtedly facilitates better fertilization management, and can therefore be regarded as a more up-to-date method than the traditional form of fertilization, but providing the necessary equipment is a question of the economic, investment and development level.

Tulcz, I.: With respect to the use of liquid fertilizers, various factors have to be taken into consideration. The most important of these is the uniform distribution of the fertilizer. This requirement in itself justifies the introduction of liquid fertilizer in agriculture as soon as possible. In my opinion, like other techniques used in countries with more developed agricultures, the application of liquid fertilizers will also become wide-spread in Hungary. The speed of this process will obviously depend on various factors, but I think we can take it for granted that it will take place.

Acta Agronomica Academiae Scientiarum Hungaricae, Tomus 29 (1–2), pp. 227–230 (1980)

LECTIONES

STUDIES ON THE MORELLA SECTION OF THE SOLANUM GENUS. V.* EVALUATION OF THE ALKALOID PRODUCTION OF SOLANUM AMERICANUM MILL.

In the course of our systematic studies on the species of the Solanum genus to find suitable starting material for steroid hormone synthesis, the plants drawn into the investigations were mostly native to Central Europe or were expected to be easy to introduce. Such species seem to be the solasodine-bearing members of the *Morella* section. Although the chemistry of many plants in this section is more or less known (SCHREIBER 1968), their evaluation for alkaloid production cannot be said to be complete, since in most cases only very few data are available on the variability of the alkaloid content and even less on the variability of the phytomass. The situation is the same in the case of *Solanum americanum* Mill. BRIGGS *et al.* (1961) established that in the fresh green berries there is 0.3% solasodine-glycoside (solasonine, solamargine, and smaller amounts of α- and β-solanigrine). BOGNÁR—MAKLEIT (1962, 1965) confirmed the presence of the first two glycosides in the shoots (0.17 dry wt. %). MÁTHÉ—MÁTHÉ (1974) also found 0.22—0.27% glycosides with solasodine aglycone in the shoots. Besides these no other data have been found in the literature which might be correlated with the alkaloid content or production. Therefore, the aim of this work is to achieve a more complet evaluation which takes the variability of the plant into account.

The plants investigated were grown in an experimental field from seeds originating from various botanic gardens. After gathering and drying the plants, the phytomasses of the organs were measured separately.

In some cases preparative isolation of the glycosides was carried out and after the hydrolysis of the glycoside mixture the solasodine content was confirmed. This method was published in an earlier paper (MÁTHÉ—MÁTHÉ 1974).

For the comparative investigations volumetric analysis was carried out. About 2 g of dried drug (at 70°C) was extracted with 0.5% nitric acid. After filtration and adjusting the acidity to 1 N with hydrochloric acid, the aglycone was precipitated from the solution with sodium hydroxide. After transferring it to filter paper and drying it, the alkaloid was extracted with chloroform in Soxhlet equipment. The basicity was established by titrating the chloroform solution with p-toluene-sulphonic acid in the presence of dimethyl yellow indicator. The results are expressed as solasodine. Parallel with every titrimetric determination, the aglycone content was checked with TLC. The carrier was silica gel G (Merck), the developing system was a 19 : 1 chloroform — methanol mixture and the spray reagent was antimony trichloride in chloroform.

* This paper was presented at the 11th International Symposium on the Chemistry of Natural Products of IUPAC at Golden Sands, Bulgaria, September 17—23rd 1978.

Table 1

Alkaloid content (dry wt. %) of S. americanum Mill. organs

	Root	Stem	Leaf	Inflo-rescence	Berry	
					green	ripe
Prepared glycoside*	0.003	0.02	0.04	—	1.69—2.34	0.03
Means of titrated aglycone	0.03	0.02	0.10	0.25	1.03	0.15

* The solasodine content is about 40% of the glycoside.

The preparative investigations confirmed the presence of solasodine in the form of glycosides in all organs of the plant. The preparative data together with the titration results are demonstrated in Table 1.

Table 1 demonstrates that the green berry has the highest alkaloid content. From the point of view of alkaloid production, the variation in the alkaloid content of the green berry seems to be the most interesting to study. Table 2 shows the means of the alkaloid content of the green berries of plants originating from five European botanic gardens but grown in our experimental field in successive years.

Table 2

Variation in the alkaloid content of the green berry in successive years

Year	n	Alkaloid (dry wt. %)	
		$\bar{X}$	$\pm s$
1973	10	1.40	0.37
1974	49	0.77	0.41
1975	46	1.10	0.31
1976	72	1.10	0.46
1977	3	0.94	0.12
Total	180	1.03	0.43

The values of standard deviation ($\pm s$) given in Table 2 and the quantity of green berries depend upon the time of harvest, i.e. on the stage of plant development. So the time-dependent variation of certain characters which might be correlated with the alkaloid production were studied in 1976 and are demonstrated in Figs. 1 and 2.

From the experimental results only the green berry appears to contain a significant amount of solasodine, while the other organs, with their much lower alkaloid content, prove to be ballast. The ripe berry does not seem to be an exception either. Its relatively higher "alkaloid" content only consists of a very small amount of solasodine (Table 1).

The alkaloid content of the green berry shows remarkable variability which could be due at least in part to the different climatic conditions of the successive years (Table 2).

The time of harvest, i.e. the stage of development of the plant, exerts a great influence on the alkaloid production. As can be seen from Fig. 1, the total above-ground phytomass increased gradually during the whole experiment (in 1976). The phytomass of the green berry

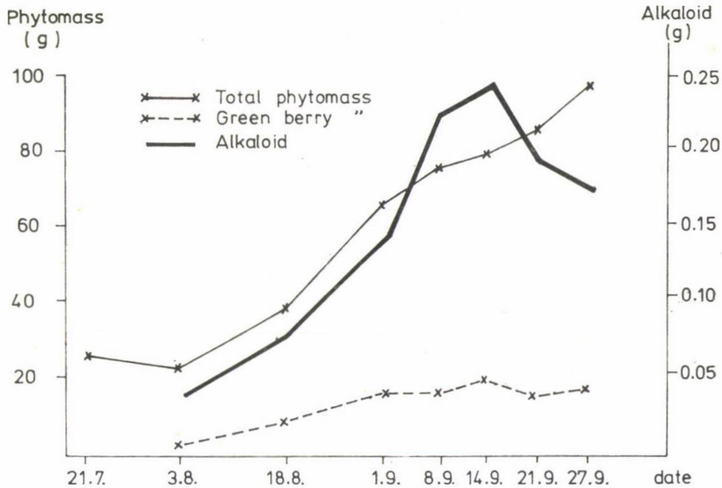


Fig. 1. Variation in the phytomass and alkaloid production per plant in the **development** period of the berry

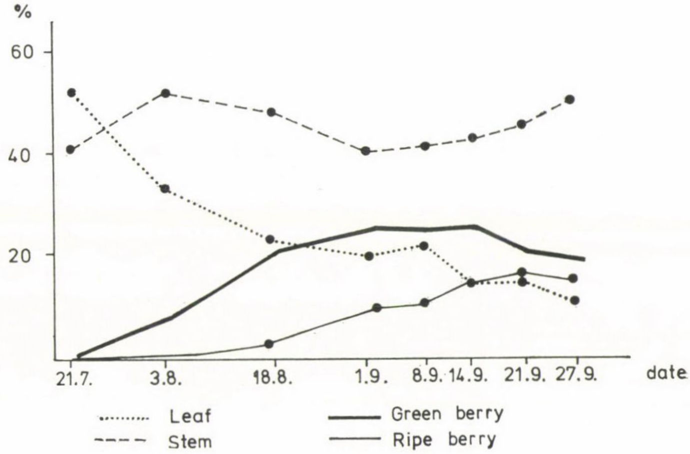


Fig. 2. Variation in the percentage distribution of the above-ground phytomass in the development period of the berry (1976)

increased more slowly and from the beginning of September onwards it was almost **unchanged.** The alkaloid content (dry wt. %) of the green berry changed somewhat more. The **fluctuation** can be well expressed by the coefficient of variation: $s\% = 14.4\%$. The corresponding **annual** mean and standard deviation of the alkaloid contents are $\bar{X} = 1.10 \pm 0.16\%$. The **alkaloid** production per plant has a maximum curve; the position of the maximum seems to be determined by the alkaloid content (dry wt. %) of the green berry. (At the maximum, it is 1.22%.) When the alkaloid content of the total above-ground phytomass is calculated, the highest figure, 0.30%, is associated with the maximum of alkaloid production.

Fig. 2 demonstrates the variation in the proportion of the various organs during the experimental period. It can be clearly seen that, surprisingly, the variation of the other organs affects neither the production of the green berry nor its relative proportion among the organs, at least near the maximum of alkaloid production.

Considering its alkaloid content, the green berry of *Solanum americanum* Mill. might be a suitable source of solasodine. The expected yield of solasodine per unit area, however, is relatively low. It might be between 8—15 kg/ha. Apart from this, the large amount of ballast could be a problem, because the alkaloid content of the total phytomass only exceeds the 0.3% level in rare cases. The ballast problem can be somewhat reduced by using a suitable method of harvesting, e.g. only the upper part of the plant is gathered after defoliation. The utilization of *Solanum americanum* Mill. as a solasodine source would only be profitable if there were a possibility of other, parallel exploitation.

*

Prepared at the Research Institute for Botany of the Hungarian Academy of Sciences, Vácrátót.

I. Máthé Jr., Hoang Van Mai, I. Máthé Sen.

References

Briggs, L. H.—Cambie, R. C.—Hoare, J. L. (1961): *Solanum* Alkaloids. XV. The Constituents of some *Solanum* Species and a Reassessment of Solasodamine and Solauricine. J. Am. Chem. Soc., 4645.

Bognár, R.—Makleit, S. (1962): Szteroidalkaloid-glikozidok V. Újabb vizsgálatok *Solanum* növények szteroidalkaloid-glikozidtartalmával kapcsolatban (Steroidalkaloid-glycosides. V. Further studies on the steroidalkaloid-glycoside content of *Solanum* plants). Magyar Kémiai Folyóirat, **68,** 432.

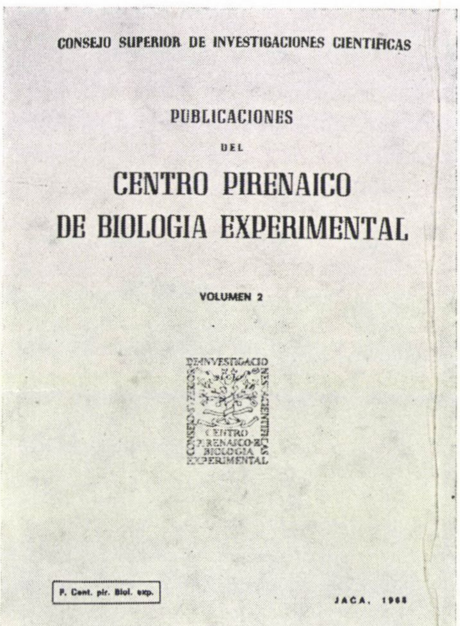
Bognár, R.—Makleit, S. (1965): Steroidalkaloidglycoside 8. Mitteilung: Zusammenfassung der eigenen bisherigen Untersuchungsergebnisse über das Vorkommen von Steroidalkaloidglycosiden in Pflanzen der Gattung *Solanum*. Pharmazie, **20,** 40.

Máthé, I. Jr.—Máthé, I. (1974): A *Solanum* genusz *Morella* szekciójának vizsgálatairól III (Studies on the *Morella* section of the *Solanum* genus III). Acta Pharmaceutica Hung., **44,** 19.

Schreiber, K. (1968): Steroid Alkaloids: The *Solanum* Group. In: Manske, R. H. F.: The Alkaloids. Chemistry and Physiology, Acad. Press, New York and London, 1—192.

Acta Agronomica Academiae Scientiarum Hungaricae, Tomus 29 (1—2), pp. 231—240 (1980)

RECENSIONES



Centro Pirenaico de biologia esperimental. 1968. Vol. 2.

The Pyrenean Centre of Experimental Biology, brought into existence by the Supreme Council of Scientific Research, began its activities in Barcelona and Jaca in 1963. A number of scientific papers from the institute have already been published. The second volume, published in 1968, supplies information on geological, botanical, zoological and zoobiological studies.

C. E. Marti Bono—C. Puigdefábregas: Estudio del Parque Nacional de Aigües Tortes y Lago de San Mauricio (Pirineos centrales): geologia y morfologia (Geological and morphological studies on the National Park in the region of Aigües Tortes and Lake Saint Mauricio, in the central Pyrenees).

The authors present a study, divided into four chapters covering 35 pages, on the area mentioned in the title. Twenty five source works were used in the study. The paper also contains maps and high quality photographs.

In the first chapter the geological history of the National Park is discussed from the Azoic through the Cambrian and Silurian eras up to the development of the mountain chain in its present form. Details are given of the changes during the Devonian and carboniferous periods, and data are provided on the "superposition" which took place in the cretaceous period and in the Miocene.

The National Park is situated in the axial zone of the Pyrenees and forms a watershed between the French and Spanish rivers.

The authors give an orographic and hydrographic description of the zone. A large part of the area is occupied by the San Nicolau and Espot valleys. The highest mountains are the Gran Tuc de Colomers (2932 m) and the Pequera (2969 m). Glaciers have formed wide grooves on them; Portárro de Espot is the most easily negotiable of the mountain passes.

The second chapter is a petrographic summarization of the area. The rocks are grouped according to geohistorical periods. Detailed descriptions are found here of ampelite, of the brownish-green shiny rocks, and of black ampelite, a rock which is very characteristic of the Pyrenees. According to the authors' investigations the limestone layer which gives the bulk of the mountain chain originates from the Devonian. A considerable proportion of the National Park is formed by granite which contains essential minerals and magnetite.

The third chapter presents data on the structure of the mountain chain.

The last chapter contains the results of the authors' investigations into the living world, and into vegetation in general.

This part includes data on the valleys found in the zone. The three districts of the Valle del Noguera de Tor (Travessany, Culieto and Biciberri) are described in detail.

P. Montserrat-Recorder: Orofitismo y endemismo en el género *Veronica* (Orophytims and endemism of the genus *Veronica*).

Studies on the plant *Veronica* began in 1954 with the purpose of identifying and examining the relationship of *V. mampodrensis* to other species, primarily to *Veronicastrum.* The characteristic features of *V. aragonensis* were also studied, and on this basis a comparison was made with the *Chamadroni-Hispano-Africanae* species.

The authors used the methods devised by Juel and Sanders in their work.

The Eurasian mountains are rich in evergreen plants of the genus *Veronica.* It extends to the tropical mountains of Africa, so its distribution somewhat resembles the distribution of the *Ericaceae.*

The author uses a number of characters to show the phylogenetic importance of the plant, and gives a list of monographs on the subject.

The species are described on the basis of herbarium data from Kew Gardens, England.

Following the works of Roempp and Stoh, the genus is divided into *Tibetanae* and *Mediterranae* groups. In this classification system the corolla and the bark are taken into consideration. On this basis the author suggests the setting up of *Macrostemonae* and *Densiflorae* sub-groups within the *Tibetanae* group.

The work describes the *Veronicastrum* series: *Gouani*, *Alpinae*, *Fruticulosae*, *Glandulosae*, *Tibetanae*, *Mediterranae.*

The paper is illustrated with 15 tables which make it extremely clear.

E. Balcells R.: Estudio general de los bitopos de las Islas Medas (General study on the biosphere of the Medas islands).

The biosphere of the Medas islands was investigated in detail in 1961—62, and data were published on the seasonal changes. The author's current paper is an augmentation of this study.

As a matter of fact, the Medas islands can be regarded as a continuation of the Macizo de Torroella de Montgri. It is in this context that the relics of the history and cultural history of the island are presented, and reference is made to the commercial importance of the islands.

The paper contains data on the climate and the meteorological characteristics of the islands. The amount of annual precipitation is 400—700 mm with a dry season in July and August. Detailed information is given on the temperature.

More than 15 species of *Angiospermae* and some 125 species of flowering plants occur on the islands. The author gives a detailed description of these.

In the course of examining the relationships between plant species and soil composition the author points out that 54% of the plants are to be found in calcareous and acidic soils alike. Halophylous and nitrophylous groups of plants are dealt with in a separate chapter.

The author establishes that the vegetation of Meda Chika is the poorest found on any of the islands.

A total of 24 bibliographic sources are quoted in the paper. The data are illustrated by 22 high quality photographs, and the distribution of the vegetation on the islands is shown on 4 maps.

C. Altimira: Moluscos terrestres en las Islas Medas (Earthworms on the Medas Islands).

The molluscs occurring on the Medas islands are described in a short two-page article. The paper is based on a study carried out by Balcells in 1961. In the paper 24 species are listed.

E. Balcells R.—F. Ferrer: Nota sobre petirrojo *(Erithacus rubecula)*, en San Juan de la Pena [Notes on the robin *(Erithacus rubecula)* in San Juan de la Pena]

The authors give a 3-page account of the growth, weight gain and nest-building habits of the robin. Data are presented on the characteristic features of robin's eggs.

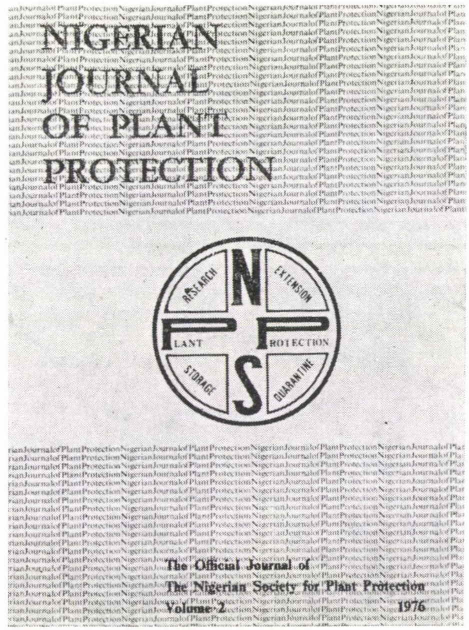
Fernando L. Rodriguez-Jiménez—E. Balcells R.: Notas biologicas sobre el alimoche, *Neophron percnopterus*, en el Alto Aragon (Biological observations of *Neophron percnopterus* in the Alto Aragon)

The authors refer to 10 bibliographic sources in their 20-page paper. The bird concerned is particularly wide-spread in the Spanish part of the Pyrenees. The migration of the birds generally takes place in the last week of March, but slight differences are observed from year to year. The eggs are laid in the first half of May, and the chicks hatch at the beginning of June. The birds leave the Pyrenees between the end of September and the beginning of October.

The paper supplies precise data on the size of the eggs, the growth of the chicks and the habits of the birds. The study is augmented with schematic illustrations and 9 photographs.

Vol. II of the Centro Pirenaico de Biologia Experimental contains a further 4 papers by J. Nadal. These are two-page papers on investigations in the sphere of zoobiology, and deal with the conditions of Na^+ and sugar metabolism and absorption.

S. TUBOLY



Nigerian Journal of Plant Protection. Nigerian Society for Plant Protection, 1976, 2.

In the African countries the level of nutrition shows extreme variations, from almost luxurious eating habits to physical starvation. This is shown by the data publiched by FAO Headquarters in connection with the fight against undernutrition and hunger in the economically backward countries where food production cannot keep pace with the rapid growth of the population.

A number of university students from Asia, Africa, Central and South America acquire in Hungary the basic knowledge required for the rapid development of food production. Under the heading "Tropical Plant Protection" they become acquainted with the chemization of crop production, the application of pesticides, the use of fertilizers, foliar and spray nutrition, and the up-to-date utilization of growth stimulators.

They can improve their special knowledge of phytopathology, plant protection, zoology, toxicology and herbology by studying foreign publications, including the journal now being reviewed. They can read, for example, about the effect of potassium on the bacterial wilting of manioca, or on the control of moulding caused by the Aspergillus species.

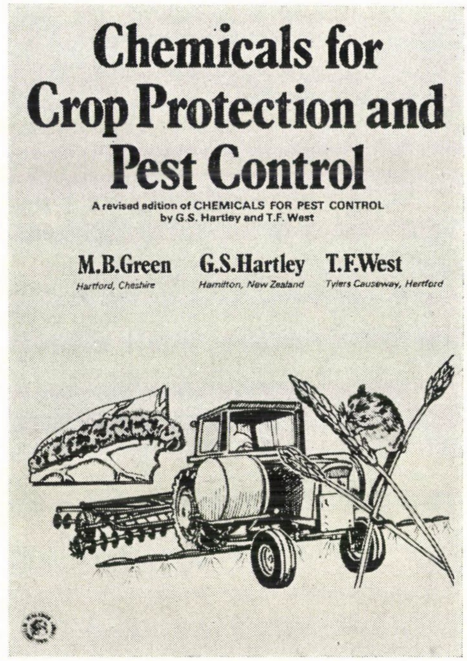
Judging by the second volume published in 1976, the list of titles should convince everybody that they can deepen their knowledge in the field of tropical plant protection. Those interested in the subject can find detailed descriptions of the wilting diseases of oil-palm seedlings, maize-ear losses caused by vertebrata, the symptoms of the rosette (virus) disease, the Cercospora leaf spots of peanut, the temperature requirements for the Colletotrichum disease of cow-pea, or the biology of Sclerotium rolfsii. The same volume deals with pest control, the application of insecticides in minimum quantities of water on cotton farms, control experiments on cocoa plantations, chemical weed control, and storage problems. There are publications on the relation between fertilization and epidemics, and an article on the phytotoxic effect of black polyethylene bags.

The line diagrams, photos and tables in the journal are clear and easy to understand. They reflect up-to-date methods of research with mathematical evaluation. The journal is equally useful for teachers, researchers, and agricultural engineers planning to go abroad, and is also welcome as an aid for university students and postgraduates from abroad.

I. PETRÓCZI

M. B. GREEN, G. S. HARTLEY and T. F. WEST: *Chemicals for crop protection and pest control*. Pergamon Press, Oxford, New York, Toronto, Sidney, Paris, Frankfurt, 291.

The book is one of a series initiated by Robert Robinson with the aim of giving university students books containing information on various branches of the chemical industry. M. B. Green, one of the authors, writes in the preface that although a considerable number of books on pesticides have recently been published, they all approach the questions of activity, selectivity, mode of action and behaviour in the environment from the point of view of biology. By contrast, this book is unique in that it examines pestic des "as products of manufacture and trade by the chemical industry".



The industrial and economic aspects are successfully amalgamated with the fundamentally chemical character of the book. It is not a scientific work in the strict sense of the word, as may be seen by the style of editing. It does not contain literary references; the relevant literature (monographs, summaries in the nature of a review) are listed at the end of each chapter, but no original publications are referred to. Consequently, statements of views connected with the name of any particular researcher, or the conclusions drawn from them, are not given. The book confines itself to presenting industrially tested results, offering a true picture of all the important chemicals currently used for crop protection and pest control, and discussing the efficiency, possibilities and limitations of chemical crop protection.

The first chapter deals with the production and economic aspects of pesticides and draws a comparison between the application of pesticides and fertilizers. It touches on parallels with the pharmaceutical industry, and examines the development of methods and efficiency in pesticide research.

The second chapter analyses the economic implications of pesticide application from the point of view of the manufacturer, the farmer and the nation. The energy balance for the use of pesticides is discussed in a further chapter. Even experts on the subject may learn much from the tables showing the energy requirements for the production and agricultural application of the most important pesticides, and, as the counterpart of this, the value of the metabolically utilizable energy originating from the use of pesticides.

A strictly practical attitude characterizes the fourth chapter, which groups the pesticides in current use according to various criteria, and attempts to correct certain nomenclatures and ways of classification which have arisen due to false interpretations. The authors put the emphasis on classification according to the way in which the pesticides reach the site of action, and thus categorize them as volatile, contact and systemic pesticides. Although the primarily chemical character of the book is repeatedly emphasized, the complete omission of the generally accepted classification according to the taxonomical place of the target organisms (insecticides, fungicides, herbicides, etc.) nevertheless leaves a sense of deficiency.

In the subsequent chapters the authors, pursuing a somewhat arbitrary and inconsequent categorization and contradicting their own principles of classification, describe the major types of pesticides.

The fifth chapter deals with mineral and vegetable oils used for crop protection and for preventing microbial damage to timber. Besides the fields of application offered by using the various oils alone, the authors mention cases where they are used as additives to increase the effect of other active agents.

The next three chapters introduce chlorinated hydrocarbon, phosphate ester and carbamate type insecticides, those belonging to other chemical groups and insecticides of natural origin. Within the individual groups of chemicals the authors present the most frequently used preparations, but for want of space do not try to include all insecticides; instead they give representative examples showing general correlations. The larger part of each of the chapters is devoted to descriptions of the chemical composition and production of the pesticides, but the authors give information on the biochemical mechanism of action as well.

The ninth chapter deals with insect repellents and attractants, as well as with substances which influence the behaviour of insects in other ways, and discusses the possibilities of their application in crop protection. In contrast to the other chapters the chemical aspects are pushed into the background, and the authors are primarily concerned with the mechanism by which the effect becomes fully manifest. The practical viewpoint which is the basic trait of the whole work assumes special importance in this chapter, as it shows the economic side of the question and thereby causes disappointment in some methods of crop protection which, owing to their novelty, have so far been judged too optimistically.

The tenth chapter contains information on chemicals used against invertebrata which cannot be included among the insects (mites, nematodes, molluscs), while the eleventh chapter describes chemicals used to control vertebrates which cause damage to cultivated plants, particularly rodents.

Three subsequent chapters discuss the chemicals used against fungal diseases in cultivated plants. Of these, two supply information on the traditional fungicides containing heavy metals, sulphur, etc., while the third gives an account of the systemic fungicides that have improved considerably during the last ten years.

The fifteenth chapter deals with herbicides and the sixteenth with growth regulators. This latter chapter, unlike the other parts of the book, lays particular emphasis on the mode of action, and discusses the practical aspects of applying growth regulators. This chapter makes exciting reading even for those familiar with the chemistry of crop protection, as it presents theoretically possible but as yet unexploited ways of increasing the yields of cultivated plants.

A separate chapter is devoted to questions of pesticide application, various technical solutions, and the physical and physico-chemical standards required of chemicals, sprays, and the distribution of the chemical on the plant surface. The next chapter is closely linked with this: it discusses the various forms of pesticides, namely, wettable powders, dusts, emulsion concentrates, aerosols, fumigants and granular preparations.

The chapter on the pesticide resistance of plants is a valuable part of the book. The causes and mechanism of the development of resistance are examined from many aspects, including morphology, biochemistry and genetics. The authors' statements are supported by some characteristic examples suitable for generalization.

The health and environmental aspects of pesticide application are discussed in the twenty-first chapter of the book, where the legal measures taken in England and the United States to eliminate the pesticide hazards threatening both consumers and the workers employed in the chemical industry and transportation are discussed.

Although the authors' aim, as shown by the title of the book, is to acquaint their readers with chemical means of crop protection, the twenty-second chapter, which summarizes the utilization of non-chemical methods of crop protection, nevertheless forms an integral part of the work. This chapter gives a true picture of the achievements, future prospects, basic conceptions and practical chances of breeding for resistance to weeds, fungi and insect pests, and gives an account of agrotechnical, biological and other non-chemical methods.

The last chapter deliberates on future possibilities. Projecting the present tendencies into the future it outlines the probable development of crop protection. Why is it that development cannot stop at its present level? Apart from the fact that the development of chemical pest control itself is continually producing new solutions, agriculture also gives rise, often precisely as a consequence of pesticide application, to situations which force the science of crop protection to renew its efforts. "As long as there is one weed species resistant to a particular herbicide, there is the possibility that this species may be a local problem, or even a national problem, when competition is removed", the authors write. The chapter discusses at length the question of how economic factors will influence the future trend of pesticide research and application. Quite understandably, the authors restrict themselves to factors which act in the capitalist system. This chapter is an outstanding part of the book, an analysis rich in original conceptions which will be new even for experts in the subject.

The whole of the work is neither more nor less than what it was intended to be: an excellently written text-book, a valuable source of information for uninitiated outsiders possessing an elementary knowledge of chemistry.

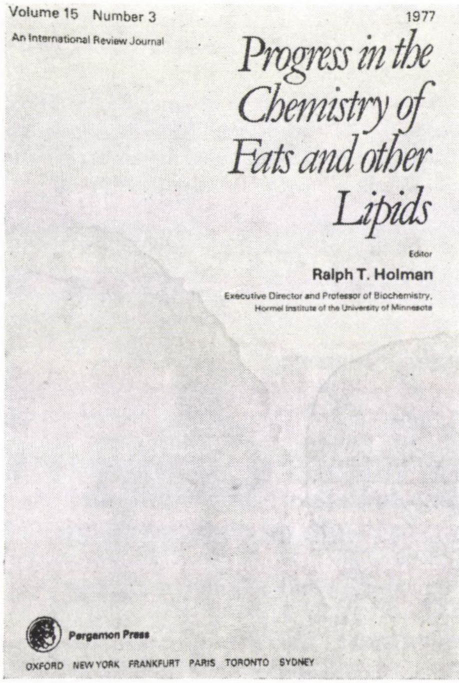
GY. MATOLCSY

WISNIAK, J.: *Jojoba oil and derivatives.* Progress Chem. Fats other Lipids, Vol. 15, 167—218. Pergamon Press, Oxford—New York—Frankfurt—Paris—Toronto—Sydney, 1977.

The new monograph "Jojoba oil and derivatives" published under the editorship of Ralph T. Holman (Executive Director and Professor of Biochemistry, Hormel Institute of University of Minnesota) in the international review "Progress in the Chemistry of Fats and other Lipids" was written by Jaime Wisniak (Department of Chemical Engineering, Ben Gurion University of the Negev, Beer Sheva, Israel).

The 51-page work contains 39 figures and 32 tables, and reference is made to 77 literary sources.

The work is in the form of a monograph, similar in structure to the monograph series on Culture Flora published by the Hungarian Academy of Sciences. The botanical, economic and phytochemical characterization is followed by a section on chemical technology.


Volume 15 Number 3 1977
An International Review Journal
Progress in the Chemistry of Fats and other Lipids
Editor
Ralph T. Holman
Executive Director and Professor of Biochemistry, Hormel Institute of the University of Minnesota
Pergamon Press
OXFORD NEW YORK FRANKFURT PARIS TORONTO SYDNEY

Simmondsia chinensis is discussed under the following headings:

I. Introduction
II. Application
III. Characteristic morphological and anatomical features of flower, fruit and seed, utilization of liquid wax during germination
IV. Jojoba oil
  A. Oil extraction
  B. Characteristics of the oil
  C. Molecular properties
  D. Toxicity
  E. Composition of jojoba oil
V. Jojoba meal
VI. Chemical transformation of the oil
  A. Cis-trans isomerization
  B. Hydrogenation
  C. Sulphurization and sulphur-chlorination
  D. Lubricating properties of sulphurized and sulphur-chlorinated derivatives
  E. Epoxidation
  F. Acrylate-methacrylate esters
  H. Ester reduction
VII. Other
Literature

The jojoba has not been dealt with in such detail before. From the monograph "The Chemical Constitution of Natural Fats" by C. P. Hilditch—P. N. Williams (1964, Chapman-Hall, London) it is known that the fruit and seed of Simmondsia californica contain highly characteristic lipids with properties similar to those of sperm whale oil. The fruit of jojoba contains wax instead of glycerides. This special liquid seed wax is completely absent from the endosperm but is localized entirely in the embryo and cotyledons. The jojoba wax is composed of esters of high carbon number aliphatic alcohols and non-drying fatty acids. According to the data of Hilditch and Williams the main fatty acid component is eicosen acid (cis-eicos-11-en acid): 64.4%, and the other is docos-13-en acid (erucic acid): 30.2%. Its oleic acid content is as low as 1.4%. Its aliphatic alcohols are docosenol (n-docos-13-enol): 70%, and eicosenol (n-eicos-11-enol): 30%.

From Wisniak's monograph we learn that *Simmondsia chinensis* (Link) Schneid., a major species of the family *Buxaceae* (the genus *Simmondsia* was earlier placed in the *Box* section of the family *Euphorbiaceae*), is arousing increasing interest in the United States, Mexico and Israel as an industrial plant. From the jojoba seed an almost completely colourless and odourless oil can be extracted with a weight ratio of 50%.

This liquiform and industrially useful wax of vegetable origin makes it possible to produce the basic raw material of many industrial products by means of crop production, instead of by gradually killing off the whale species which are already protected. Today the whole world is concerned with nature conservation; it is a well-known fact that the flora and fauna of the oceans, including the largest mammals in the world, are seriously threatened.

Since the jojoba is a native plant of South Arizona, North-West Mexico and the neighbouring areas (which is why the name S. californica is used instead of S. chinensis), its cultivation also provides employment for Red Indians living in reservations in the region. The Arizona University (Tucson) and the California University (Riverside) have therefore elaborated a detailed plantation and processing plan with a view to profitable jojoba cultivation. Jojoba could also be grown on other semiarid areas and might thus be a promising crop in other parts of the world as well.

Jojoba oil has several advantages over sperm whale oil: it does not smell of fish, does not contain stearine when fresh, can be sulphurized without darkening, and remains in a liquid state after sulphurization.

Wisniak mentions that the oil obtained from jojoba seed was used by the Red Indians as hair lotion, and for eating, therapeutic and ritual purposes even before the European colonists arrived. Today it is used widely in industry. As it is tolerant to high temperature and pressure, it is an excellent lubricant. It has a high dielectric constant, so it is a first class transformer oil. It can be used not only in the manufacture of linoleum but also in carbon paper and stencil production, and it is a component of many pharmaceutical and cosmetic products. Since jojoba oil is easy to hydrogenate, a particularly hard wax with a high melting point can be obtained from it, which can vie with bee's wax, candelilla, carnauba and spermaceti wax. The C_{20} and C_{22} linear carbon chain alcohols which can be extracted from the oil are valuable basic materials in producing detergents, wetting agents and other derivatives.

The botanical and morphological characterization deals mainly with the fruit and seed of Simmondsia chinensis. It is an interesting statement that the wax stored in the cotyledons of the germinating seed first decomposes into smaller molecules which then penetrate into the embryo and are utilized there. The anatomical description of the seed is followed by a detailed chemical characterization. The text, which is illustrated by tables and diagrams, provides information on the chemical and technological properties of jojoba oil. The evaluation is greatly helped by comparisons between jojoba oil and other oils used in a similar manner.

During his discussion of extraction methods the author gives information on the efficiency of various solvents and the lipid composition of the extracted product. To mention a few of the physico-chemical and mechanical properties of jojoba oil: freezing point: 10.6 – 7.0°C; melting point: 6.8 – 7.0°C; dielectric constant: 2.680 (at 27°C); specific gravity: 0.863; viscosity: 35 cp; fire point: 338°C; iodine value: 82; acid value: 2.

From a practical point of view it is important to know the physico-chemical bases of hydrogenation. The solubility of hydrogen is in direct proportion to the pressure and temperature used. This fact is clearly shown by the NMR spectra and the differential-scanning calorimetric thermograms.

The section on the chemical composition of jojoba oil is particularly interesting. The jojoba meal is the 50% by weight remaining after oil extraction. It is noteworthy that this meal contains 31.5% protein. It is also rich in lysine (5.7%) and arginine (7.8%), while the methionine content is relatively low (0.4%).

The oil-free meal contains 3 – 4% simmondsine, a digestion inhibitor. The structure of this toxic compound is given as 2-cyano-methylene-3-hydroxy-4.5 dimethocyclohexyl β-D-glucoside, which causes acute toxicity ($LD_{50} > 4$ g kg^{-1}) in the organism when introduced orally. The simmondsine content can be reduced by a lengthy treatment with ammonia; jojoba meal thus treated causes a weight gain when added to the feed at a ratio of 15%.

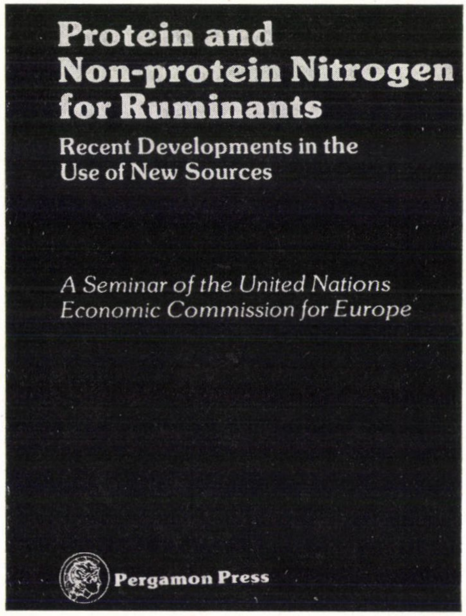
The fatty acid and alcohol compositions of jojoba oil are determined by gas chromatography and mass spectrometry. Of the 21 fatty acids identified eicos-11-en acid makes up 71.3%, and docos-13-en acid 13.6%. Of the 12 alcohols eicos-11-enol and docos-13-enol are found in the largest proportions (43.8 and 44.9%, respectively). That is, 43.2% of the wax esters of jojoba oil is docosenil eicosenate and 30.9% is eicosenil eicosenate.

The chapter discussing the chemical treatment and transformation of the oil is of great value. It gives a full theoretical and practical survey of the catalytic equilibrium of hydrogenation, the factors promoting the catalysis, the properties of the hydrogenated wax, the efficiency of sulphurization and sulphurchlorination with sulphur chloride, and of the lubricating properties of derivatives thus obtained, and the production of wax alcohols obtained by ester reduction.

At the end of this comprehensive work the author lists various kinds of results. Particularly interesting is the statement that in in vitro experiments jojoba oil prevents the reproduction of Mycobacterium tuberculosis, probably by exerting a hydrolytic or dissolving action on the external lipid layer of the bacillus. The antifoaming effect of jojoba oil is very useful in producing penicillin and cephalosporine by fermentation, and causes an increase in the yield of antibiotic.

Wisniak's monograph on jojoba oil is highly instructive not only for researchers directly interested in its utilization, but for anyone working with fats of vegetable and animal origin. Much is expected from this new industrial plant in the coming years; its world importance will only be fully felt in the new millenium.

L. GY. SZABÓ



Protein and non-protein nitrogen for ruminants. Published for the United Nations by Pergamon Press Ltd, London, 1977.

Proceedings of the Symposium on Recent Developments in the Use of New Sources of Protein, Essential Amino Acids and Non-protein Nitrogen, With Special Reference to Ruminants.

The Symposium was held at the Palais des Nations, Geneva, from 10 to 13 January 1977. The symposium was jointly organized by the Committee on Agricultural problems of the United Nations Economic Commission for Europe (ECE) and the Food and Agriculture Organization of the United Nations (FAO). Fifty-six participants from seventeen countries and from two international organizations attended the symposium, which met under the chairmanship of Professor N. A. Shmanenkov, Director of the All-Union Research Institute of Physiology and Biochemistry and Nutrition of Animals of the USSR. Professor W. Kaufmann, of the Institute of Dairy Production, Federal Dairy Research Centre (Federal Republic of Germany), served as Vice-Chairman.

The programme for the Symposium, drawn up by the secretariats of the ECE and the FAO, enabled the participants to discuss the requirements of both dairy and beef cattle for protein, essential amino acids and non-protein nitrogen, and new sources of these nutrients, and secondly, the economic and other considerations which govern decisions on incorporating additional and new sources of protein and non-protein nitrogen into the diet of both categories of animal.

The proceedings consist of the report of the symposium, seven main reports and seven additional papers.

The Symposium was attended by 56 experts representing governments, research institutes and industry in the following countries: Belgium; Czechoslovakia; Denmark; Finland; France; German Democratic Republic; German Federal Republic; Hungary; Italy; Netherlands; Poland; Sweden; Switzerland; United Kingdom; United States of America; and the Union of Soviet Socialist Republics.

The programme and the reports of the Symposium consisted of the following topics:

Views on the requirements of dairy cattle for protein, essential amino acids and non-protein nitrogen, and new sources of these nutrients suitable for use in the feeding of dairy cattle. Rapporteurs: Prof. N. A. Shmanenkov, Director of the All-Union Research Institute of Physiology and Biochemistry of Animal Husbandry, Borovsk, USSR, Mr. S. Tamminga, Research Institute of Animal Feeding and Nutrition, Hoorn, Lelystad, Netherlands, and Dr. K. K. van Hellemond, Institute of Investigation of Biochemical Products, Wageningen, Netherlands.

Economic and other considerations governing decisions on the advisability of incorporating additional and new sources of protein and non-protein nitrogen into the diet of dairy cattle. Rapporteurs: Dr. P. D. Möller and Prof. A. Neimann-Sörensen, National Institute of Animal Science, Department of Cattle Experiments, Copenhagen, Denmark.

Views on the requirements of beef cattle (including fattening cattle) for protein, essential amino acids and non-protein nitrogen, and new sources of protein, these nutrients suitable for use in the feeding of beef cattle (including fattening cattle). Rapporteurs: Prof. S. Poppe, Director of the Department of Animal Production, and Mr. M. Gabel, University of Rostock, German Democratic Republic, Mr. Journet, Research Director, and Mr. Y. Geay, Research Centre INRA, Domaine de Theix, Beaumont, France.

Economic and other considerations governing decisions on the advisability of incorporating additional and new sources of protein and non-protein nitrogen into the diet of beef cattle (including fattening cattle). Rapporteurs: Prof. W. Kaufmann, Institute of Dairy Production, Federal Dairy Research Centre, Kiel, Federal Republic of Germany, and Dr. S. Szentmihályi, Research Institute for Animal Husbandry, Herceghalom, Hungary.

In additon to these, the following papers were submitted:

Protein standards and nitrogen sources (natural protein versus non-protein nitrogen) for young fattening bulls.

Preparation of fatty-acid/carbamide adducts and application of the product for fattening ruminants.

Protein requirements and non-protein nitrogen — supplementation in fattening bulls.

Experience with the use of synthetic non-protein nitrogen — compounds in cattle nutrition in Czechoslovakia.

The use of non-protein nitrogen — sources in rations for intensive beef production.

The use of non-protein nitrogen in cattle diets.

Minimum protein requirements for milking cows.

The important new features brought out in the papers presented and in the discussion were the following:

Dairy cattle: Substituting non-protein nitrogen (NPN) for plant protein in rations for dairy cows is possible under certain conditions, of which the level of production seems to be among the most important. The special problems of providing optimum protein and energy for high-yielding dairy cows in the first one to two months of lactation seem likely to leave little opportunity for effective utilization of added NPN for such cows. In view of these difficulties the use of protected proteins promises to be an important means of improving the situation. Technological processes should be further developed.

Beef and fattening cattle: Recent research in various countries indicates that the protein requirements of beef and fattening cattle are lower than was assumed in the past, if appropriate energy sources are fed. The inclusion of NPN in rations for beef and fattening cattle appears to be more promising than for dairy cattle. The potential of several new NPN sources was discussed.

B. Juhász

Acta Agronomica Academiae Scientiarum Hungaricae, Tomus 29 (1–2), pp. 241–245 (1980)

AUCTORES

ABO-KORAH S. M.
Plant Protection Department,
Faculty of Agriculture,
University of Menoufia,
Cairo,
Egypt

ANDERSEN B. B.
National Institute of Animal Science,
Copenhagen,
Denmark

ÁCS A.
DATE Alkalmazott Üzemtani Tanszék,
4001 Debrecen,
Böszörményi út 138.
Hungary

BARACS J.
Baranya megyei Tanács VB,
Mezőgazdasági és Élelmezésügyi Osztálya,
7601 Pécs,
Széchenyi tér 9.
Hungary

BAUER F.
Zöldségtermesztési Kutatóintézet,
6000 Kecskemét,
Kisfái 10.
Hungary

BEKE F.
GKI Kutatóállomása,
9761 Táplánszentkereszt,
Hungary

BEKE I.
Középtiszai ÁG,
5340 Kunhegyes,
Szabadság tér 9—10.
Hungary

BODÓ I.
ÁE Állattenyésztéstani Tanszék,
1400 Budapest,
Rottenbiller u. 23—25.
Hungary

BUZÁS I.
Növényvédelmi és Agrokémiai Központ,
1118 Budapest,
Budaörsi út 141—145.
Hungary

CSILLÉRY M.
Hunyadi Mgtsz.
7018 Pusztaegres,
Hungary

DARWISH A.
Department of Animal Production,
Faculty of Agricultural,
Assiut University,
Assiut,
Egypt

DEBRECZENI B.
GATE Mezőgazdasági Kémiai Tanszék,
2103 Gödöllő
Hungary

DEBRECZENI I.
DATE Növénytermesztési Tanszék,
5540 Szarvas,
Szabadság út 1—3.
Hungary

DOHY J.
MF Állattenyésztési Tanszék,
7400 Kaposvár
Dénesmajor 2.
Hungary

DUNAY A.
ÁE Állattenyésztéstani Tanszék,
1400 Budapest,
Rottenbiller u. 23—25.
Hungary

ERDŐS L.
ELTE Meteorológiai Tanszék,
1088 Budapest,
Múzeum krt. 6—8.
Hungary

FAZEKAS S.
SOTE II. sz. Kémiai-Biokémiai Intézet,
1088 Budapest,
Puskin u. 9.
Hungary

FEHÉR D.
KE Kémiai Tanszék,
1114 Budapest,
Villányi út 29—31.
Hungary

GOMBKÖTŐ G.
KE Kémiai Tanszék,
1114 Budapest,
Villányi út 29—31.
Hungary

GYŐRI D.
KATE Talajtani Tanszék,
8361 Keszthely,
Deák Ferenc u. 16.
Hungary

HAFEZ A. A.
Department of Horticultural,
Faculty of Agriculture,
Cairo University,
Cairo,
Egypt

HAFIZ G. A.
Department of Animal Production,
Faculty of Agricultural,
Assiut University,
Assiut,
Egypt

HARASZTI E.
ÁTE Növénytani Tanszék,
1077 Budapest,
Rottenbiller u. 50.
Hungary

HARMATI I.
Gabonatermesztési Kutatóintézet,
6701 Szeged,
Alsókikötősor 9.
Hungary

HEFNI E. S.
Agronomy Department,
Faculty of Agricultural Science,
Mostohor, Kalubia,
Egypt

HELMECZI B.
DATE Talajtani és Mikrobiológiai Tanszék,
4001 Debrecen,
Böszörményi út 138.
Hungary

HOANG VAN MAI
MTA Botanikai Kutatóintézete,
2163 Vácrátót
Hungary

HORVÁTH J.
KATE Növényvédelmi Intézet,
8361 Keszthely,
Deák Ferenc u. 16.
Hungary

HUSTI M.
Babarci Béke Mgtsz.
7753 Szajk,
Petőfi u. 163.
Hungary

JÁVORKA L.
Állattenyésztési Kutatóintézet,
2053 Herceghalom,
Hungary

JUHÁSZ B.
ÁKI Élettani Osztály,
1024 Budapest,
Kitaibel Pál u. 4.
Hungary

KÁDÁR Ö.
KE Kémiai Tanszék,
1114 Budapest,
Villányi út 29—31.
Hungary

KÁSA I.
BME Alkalmazott Kémiai Tanszék,
Egry József u. 20—22.
Hungary

KEMENESY E.
KATE Növénytermesztéstani Tanszék,
8360 Keszthely,
Deák Ferenc u. 16.
Hungary

KHEREBA A. H.
Department of Horticultural,
Faculty of Agriculture,
Cairo University,
Cairo,
Egypt

KISS A. S.
BVK Agrokémiai Osztály,
3700 Kazincbarcika,
Hungary

KISS Á.
Zöldségtermesztési Kutatóintézet,
6000 Kecskemét,
Hungary

KOLTAY Á.
MTA Mezőgazdasági Kutatóintézete,
2462 Martonvásár,
Hungary

Kováts A.
KATE Növénytermesztéstani Tanszék,
8361 Keszthely,
Deák Ferenc u. 16.
Hungary

Kükedi E.
MTA Mezőgazdasági Kutatóintézete,
2462 Martonvásár,
Hungary

Láng G.
KATE Növénytermesztéstani Tanszék,
8361 Keszthely,
Deák Ferenc u. 16.
Hungary

Lohonyai N.
KE Kémiai Tanszék,
1114 Budapest,
Villányi út 29—31.
Hungary

Lőrincz J.
GATE Földműveléstani és Növénytermesztési Tanszék,
2103 Gödöllő
Hungary

Mathur M.
Mycology Laboratorium,
Department of Botany,
University of Delhi,
Delhi-7,
India

Matolcsy Gy.
Növényvédelmi Kutatóintézet,
1022 Budapest,
Herman O. u. 15.
Hungary

Máthé I. Jr.
MTA Botanikai Kutatóintézete,
2163 Vácrátót,
Hungary

Máthé I. Sen.
MTA Botanikai Kutatóintézete,
2163 Vácrátót,
Hungary

Mihályfalvy I.
Gyümölcs- és Dísznövénytermesztési Kutatóintézet,
1223 Budapest,
Park u. 2.
Hungary

Molnár F.
Jóreménység Mgtsz.
8125 Sárkeresztúr
Hungary

Molnár J.
Bácsalmási Állami Gazdaság,
6430 Bácsalmás,
Zrínyi u. 8.
Hungary

Mosselhy S.
Department of Animal Production,
Faculty of Agricultural,
Assiut University,
Assiut,
Egypt

Mukerji K. G.
Mycology Laboratorium,
Department of Botany,
University of Delhi,
Delhi-7,
India

Nagy M.
JATE Növényélettani Tanszék,
6722 Szeged,
Egyetem u. 2.
Hungary

Nath R.
Mycology Laboratorium,
Department of Botany,
University of Delhi,
Delhi-7,
India

Nyéki J.
KATE Növénytermesztéstani Tanszék,
8361 Keszthely,
Deák Ferenc u. 16.
Hungary

Osman A. A.
Plant Protection Department,
Faculty of Agriculture,
University of Menoufia,
Cairo,
Egypt

Óváry I.
SOTE Psychiatriai Klinika,
1083 Budapest,
Balassa u. 6.
Hungary

Pais I.
KE Kémiai Tanszék,
1114 Budapest,
Villányi út 29—31.
Hungary

Pál Gy.
Acta Agron. Hung. Szerkesztősége,
2462 Martonvásár,
Postafiók 19.
Hungary

PECZNIK J.
GATE Mezőgazdasági Kémiai Tanszék,
2103 Gödöllő
Hungary

PETRASOVITS I.
GATE Vízgazdálkodási és Meliorációs Tanszék,
2103 Gödöllő,
Hungary

PETRÓCZI I.
GATE Növényvédelemtani Tanszék,
2103 Gödöllő,
Hungary

PLETSER J.
Központi Légkörfizikai Intézet,
Agrometeorológiai Obszervatóriuma,
2462 Martonvásár,
Hungary

POSGAY E.
Öntözési Kutatóintézet,
5541 Szarvas,
Szabadság út 2.
Hungary

POZSÁR B. I.
MTA Izotóp Intézete,
1525 Budapest,
Konkoly Thege út
Hungary

RAJKI E.
MTA Mezőgazdasági Kutatóintézete,
2462 Martonvásár,
Hungary

RAKONCZAY Z.
Országos Környezet- és Természetvédelmi Hivatal,
1121 Budapest,
Költő u. 21.
Hungary

ROMÁNY P.
Mezőgazdasági és Élelmezésügyi Minisztérium,
1055 Budapest,
Kossuth Lajos tér 11.
Hungary

SARMA S. K.
KE Növénytani Tanszéke,
1118 Budapest,
Ménesi út 44.
Hungary

SEMJÉN I.
Szovjet—Magyar Barátság Mgtsz.
8151 Szabadbattyán,
Hungary

SHMILLÁR M.
Cukortermelési Kutatóintézet,
Répatermesztési Kutatóállomása,
9463 Sopronhorpács,
Hungary

SURÁNYI D.
GYDKI Kutató Állomása,
2701 Cegléd,
Szolnoki út 52.
Hungary

SUTKA J.
MTA Mezőgazdasági Kutatóintézete,
2462 Martonvásár,
Hungary

SZABÓ B.
Lenin Mgtsz.
5431 Tiszaföldvár,
Hungary

SZABÓ L. GY.
Kutatóállomás Bicsérd,
7940 Szentlőrinc,
Hungary

SZABÓ Z.
KE Kémiai Tanszék,
1114 Budapest,
Villányi út 29—31.
Hungary

SZALAI GY.
GATE Kutatóintézete,
3356 Kompolt,
Hungary

SZALAY S.
MTA Atommag Kutatóintézete,
4001 Debrecen,
Bem tér 18/c.
Hungary

SZENICZEY CS.
Tata és Vidéke ÁFÉSZ,
2891 Tata II.
Bartók F. u. 9.
Hungary

SZÉKESSY-HERMANN V.
SOTE II. sz. Kémiai-Biokémiai Intézet,
1088 Budapest,
Puskin u. 9.
Hungary

TARJÁN R.
Országos Élelmezéstudományi Intézet,
1097 Budapest,
Gyáli út 3/a.
Hungary

TELEGDI L.
MTA Számítástechnikai és Automatizálási Kutatóintézete,
Biomatematikai Csoport,
1111 Budapest,
Kende u. 13—17.
Hungary

TERPÓ A.
KE Növénytani Tanszék,
1118 Budapest,
Ménesi út 44.
Hungary

THYSEN I.
National Institute of Animal Science,
Copenhagen,
Denmark

TOMPA GY.
Szekszárdi ÁG,
KSZE Iroda,
7100 Szekszárd,
Borkombinát,
Hungary

TÖLGYESI GY.
1172 Budapest,
Kőtelek u. 12.
Hungary

TUBOLY S.
ÁTE Járványtani Tanszék,
1581 Budapest,
Hungária krt. 23.
Hungary

TUKACS O.
MTA Mezőgazdasági Kutatóintézete,
2462 Martonvásár
Hungary

TULCZ I.
Győzelem Mgtsz.
8136 Lajoskomárom,
Hungary

ZOHDY G. I.
Plant Protection Department,
Faculty of Agriculture,
University of Menoufia,
Cairo,
Egypt

INDEX

LECTIONES

RECENSIONES

AUCTORES

INDEX

EUPHYTICA

NETHERLANDS JOURNAL OF PLANT BREEDING,

Lawickse Allee 166, WAGENINGEN.

Vol. 26 (1977) (852 pages) contains 101 articles. Some are:

Selection for yield in early generations of self-fertilizing crops; More arguments intermating F_2 plants of a self-fertilizing crop; The integrated concept of disease resistance: A new view including horizontal and vertical resistance in plants; Genetic and plant breeding interpretations of the effects of bulk breeding on four populations of beans *(Phaseolus vulgaris* L.); Protoplast technology in relation to crop plants: progress and problems; On the problem of preharvest sprouting of wheat; Polyploidy in tulips *(Tulipa* L.); Pollen longevity and artificial cross-pollination in *Coffea arabica* L.; Hybrid Tea-rose pollen; The importance of wild germplasm in plant breeding.

Published three times a year, in annual volumes of about 800 pages.

Subscription vol. 27 (1978) 85 guilders (about $ 34) a year.
vols. 2 (1953) – 25 (1976) at 65 guilders per volume (about $ 25) + postage
vol. 26 (1977) 85 guilders (about $ 34) a year
vol. 1 (1952) reprinted, $ 12.50 + postage

Correspondence should be addressed to:
The Managing Editor, Euphytica
c/o Institute of Plant Breeding (I.v.P.),
Lawickse Allee 166,
WAGENINGEN.
The Netherlands.

ANNOUNCEMENT

Within the framework of the bilateral agreement between the Hungarian Academy of Sciences and the Royal Swedish Academy of Sciences, a joint workshop was organised in Hungary on June 5—9th 1978 with the title „Agricultural potentiality directed by nutritional needs".

The workshop was mainly concerned with the problem of how to double the quantity of food available for human nutrition and how to improve its quality by the year 2000.

The Hungarian Academy of Sciences invited 2 or 3 specialits from each of the European socialist countries (Bulgaria, Czechoslovakia, German Democratic Republic, Jugoslavia, Poland, Romania, Soviet Union) to participate at the workshop, including at least one specialist in the field of food production and one in the field of human nutrition.

The Royal Swedish Academy of Sciences invited 2 or 3 specialists in the same fields from each of the Nordic countries (Denmark, Finland, Iceland, Norway).

Representatives were also present from UNESCO, FAO, WHO-, ICSU and the UN University.

The organising committee, made up of Swedish and Hungarian specialists, proposed the following subjects for discussion at the workshop:

1) Human nutritional needs with special reference to balance between protein, carbohydrates, fat and vitamins at different levels of food supply.

2) Malnutrition, a problem of undernourishment but also of overnourishment.

3) Genetic potentials for improvements of crop yield and nutritional quality.

4) Possibilities for improvements of animal production under consideration of human nutritional needs.

A full report on the workshop, including papers, contributions and discussion, will be published in English as a supplement to the 1978 issue of our journal.

PROCEEDINGS OF THE 4TH INTERNATIONAL CONGRESS OF ACAROLOGY

Ed. by E. Piffl

The volume is divided into twelve sections, each dealing with topics of current interest: General and experimental taxonomy; Physiology and genetics; Soil Acari; Marine and freshwater Acari; Mites associated with plants; Mites of stored products; Parasitic mites; Ticks; Acari and diseases; Biological control, Chemical control and Techniques. In addition, there are four further sections discussed under the following titles: Form and function of acarine mouth parts; Nutrition; Nidicolous mites; Fine structure.

In English — Approx. 550 pages — Numerous photographs — 17 × 25 cm — ISBN 963 05 1695 0 — Cloth

Mohamed Ali Mohamed Ali:

ECOLOGICAL AND PHYSIOLOGICAL STUDIES ON THE ALFALFA LADYBIRD

The alfafa ladybird is a common pest in Hungary as well as in other countries o Central Europe. The author studied the causes of changes in the individual density of populations brought about by the conditions of diapause, overwintering, temperature, humidity, length of the light period, as well as the anatomical, physiological and biochemical changes in the insect organism. The work provides basic knowledge for insect physiologists and entomologists and presents basis also for alfalfa ladybird control in alfalfa stands.

In English — Approx. 260 pages — ISBN 963 05 1702 7 — Cloth

AKADÉMIAI KIADÓ, Budapest
Publishing House of the Hungarian Academy of Sciences

Printed in Hungary

A kiadásért felel az Akadémiai Kiadó igazgatója — Műszaki szerkesztő: Botyánszky Pál
A kézirat nyomdába érkezett: 1979. VI. 13. — Terjedelem: 22,25 (A/5) ív, 43 ábra

80.7245 Akadémiai Nyomda, Budapest — Felelős vezető: Bernát György

Die Acta Agronomica veröffentlichen agrarwissenschaftliche Abhandlungen, besonders aus dem Bereich der landwirtschaftlichen Grundforschung, in englischer Sprache.

Die Acta Agronomica erscheinen jährlich in einem Band (4 Hefte).

Die zur Veröffentlichung bestimmten Manuskripte sind an folgende Adresse zu senden:

Acta Agronomica
H-2462 Martonvásár, Postafiók 19.

Abonnementspreis pro Band: $ 36.00.

Bestellbar bei »Kultúra« Außenhandelsunternehmen (H-1389 Budapest 62, P. O. B. Bankkonto Nr. 218-10-990) oder seinen Auslandsvertretungen.

Les Acta Agronomica publient des communications, en langue anglaise, dans le sujet de la science agricole, surtout du domaine des recherches fondamentales agronomiques.

Les Acta Agronomica sont publiés sous forme de fascicules qui seront réunis en un volume par an.

On est prié d'envoyer les manuscrits destinés à la rédaction à l'adresse suivante:

Acta Agronomica
H-2462 Martonvásár, Postafiók 19.

Le prix de l'abonnement: $ 36.00 par volume.

On peut s'abonner à l'Entreprise du Commerce Extérieur « Kultúra » (H-1389 Budapest 62, P. O. B. 149, Compte-courant No. 218-10-990) ou chez représentants à l'étranger.

Acta Agronomica публикает статьи по аграрной тематике, главным образом теоретические работы в области сельскохозяйственных основных наук.

«Acta Agronomica» выходит выпусками, составляющими один том в год.

Предназначенные для публикации рукописи следует направлять по адресу:

Acta Agronomica
H-2462 Martonvásár, Postafiók 19.

Подписная цена — $ 36.00 за том.

Заказы принимает предприятие по внешней торговле «Kultúra» (H-1389 Budapest 62, P. O. B. 149, Текущий счет № 218-10-990) или его заграничные представительства и уполномоченные.

Reviews of the Hungarian Academy of Sciences are obtainable at the following addresses:

AUSTRALIA
C.B.D. LIBRARY AND SUBSCRIPTION SERVICE, Box 4886, G.P.O., *Sydney N.S.W. 2001*
COSMOS BOOKSHOP, 145 Ackland Street, *St. Kilda (Melbourne), Victoria 3182*

AUSTRIA
GLOBUS, Höchstädtplatz 3, *1200 Wien XX*

BELGIUM
OFFICE INTERNATIONAL DE LIBRAIRIE, 30 Avenue Marnix, *1050 Bruxelles*
LIBRAIRIE DU MONDE ENTIER, 162 Rue du Midi, *1000 Bruxelles*

BULGARIA
HEMUS, Bulvar Ruski 6, *Sofia*

CANADA
PANNONIA BOOKS, P.O. Box 1017, Postal Station "B", *Toronto, Ontario M5T 2T8*

CHINA
CNPICOR, Periodical Department, P.O Box 50, *Peking*

CZECHOSLOVAKIA
MAD'ARSKÁ KULTURA, Národni třida 22, *115 66 Praha*
PNS DOVOZ TISKU, Vinohradská 46, *Praha 2*
PNS DOVOZ TLAČE, *Bratislava 2*

DENMARK
EJNAR MUNKSGAARD, Norregade 6, *1165 Copenhagen*

FINLAND
AKATEEMINEN KIRJAKAUPPA, P.O. Box 128, *SF-00101 Helsinki 10*

FRANCE
EUROPERIODIQUES S. A., 31 Avenue de Versailles, *78170 La Celle St.-Cloud*
LIBRAIRIE LAVOISIER, 11 rue Lavoisier, *75008 Paris*
OFFICE INTERNATIONAL DE DOCUMENTATION ET LIBRAIRIE, 48 rue Gay-Lussac, *75240 Paris Cedex 05*

GERMAN DEMOCRATIC REPUBLIC
HAUS DER UNGARISCHEN KULTUR, Karl-Liebknecht-Strasse 9, *DDR-102 Berlin*
DAUTSCHE POST ZEITUNGSVERTRIEBSAMT, Strasse der Pariser Kommüne 3—4, *DDR-104 Berlin*

GERMAN FEDERAL REPUBLIC
KUNST UND WISSEN ERICH BIEBER, Postfach 46, *7000 Stuttgart 1*

GREAT BRITAIN
BLACKWELL'S PERIODICALS DIVISION, Hythe Bridge Street, *Oxford OX1 2ET*
BUMPUS, HALDANE AND MAXWELL LTD., Cowper Works, *Olney, Bucks MK46 4BN*
COLLET'S HOLDINGS LTD., Denington Estate. *Wellingborough, Northants NN8 2QT*
WM. DAWSON AND SONS LTD., Cannon House, *Folkestone, Kent CT19 5EE*
H. K. LEWIS AND CO., 136 Gower Street, *London WC1E 6BS*

GREECE
KOSTARAKIS BROTHERS, International Booksellers, 2 Hippokratous Street, *Athens-143*

HOLLAND
MEULENHOFF-BRUNA B.V., Beulingstraat 2, *Amsterdam*
MARTINUS NIJHOFF B.V., Lange Voorhout 9—11, *Den Haag*
SWETS SUBSCRIPTION SERVICE, 347b Heereweg, *Lisse*

INDIA
ALLIED PUBLISHING PRIVATE LTD., 13/14 Asaf Ali Road, *New Delhi 110001*
150 B-6 Mount Road, *Madras 600002*
INTERNATIONAL BOOK HOUSE PVT. LTD., Madame Cama Road, *Bombay 400039*
THE STATE TRADING CORPORATION OF INDIA LTD., Books Import Division, Chandralok, 36 Janpath, *New Delhi 110001*

ITALY
EUGENIO CARLUCCI, P.O. Box 252, *70100 Bari*
INTERSCIENTIA, Via Mazzé 28, *10149 Torino*
LIBRERIA COMMISSIONARIA SANSONI, Via Lamarmora 45, *50121 Firenze*
SANTO VANASIA, Via M. Macchi 58, *20124 Milano*
D. E. A., Via Lima 28, *00198 Roma*

JAPAN
KINOKUNIYA BOOK-STORE CO. LTD., 17-7 Shinjuku-ku 3 chome, Shinjuku-ku, *Tokyo 160-91*
MARUZEN COMPANY LTD., Book Department, P.O. Box 5050 Tokyo International, *Tokyo 100-31*
NAUKA LTD. IMPORT DEPARTMENT, 2-30-19 Minami Ikebukuro, Toshima-ku, *Tokyo 171*

KOREA
CHULPANMUL, *Phenjan*

NORWAY
TANUM-CAMMERMEYER, Karl Johansgatan 41—43, *1000 Oslo*

POLAND
WĘGIERSKI INSTYTUT KULTURY, Marszalkowska 80, *Warszawa*
CKP I W ul. Towarowa 28 *00-958 Warszawa*

ROUMANIA
D. E. P., *Bucureşti*
ROMLIBRI, Str. Biserica Amzei 7, *Bucureşti*

SOVIET UNION
SOJUZPETCHATJ — IMPORT, *Moscow*
and the post offices in each town
MEZHDUNARODNAYA KNIGA, *Moscow G-200*

SPAIN
DIAZ DE SANTOS, Lagasca 95, *Madrid 6*

SWEDEN
ALMQVIST AND WIKSELL, Gamla Brogatan 26, *S-101 20 Stockholm*
GUMPERTS UNIVERSITETSBOKHANDEL AB, Box 346, *401 25 Göteborg 1*

SWITZERLAND
KARGER LIBRI AG, Petersgraben 31, *4011 Basel*

USA
EBSCO SUBSCRIPTION SERVICES, P.O. Box 1943, *Birmingham, Alabama 35201*
F. W. FAXON COMPANY, INC., 15 Southwest Park, *Westwood, Mass, 02090*
THE MOORE-COTTRELL SUBSCRIPTION AGENCIES, *North Cohocton, N. Y. 14868*
READ-MORE PUBLICATIONS, INC., 140 Cedar Street, *New York, N. Y. 10006*
STECHERT-MACMILLAN, INC., 7250 Westfield Avenue, *Pennsauken N. J. 08110*

VIETNAM
XUNHASABA, 32, Hai Ba Trung, *Hanoi*

YUGOSLAVIA
JUGOSLAVENSKA KNJIGA, Terazije 27, *Beograd*
FORUM, Vojvode Mišića 1, *21000 Novi Sad*

8. II. 1980

Index: 26.001
HU ISSN 0001—513X

ACTA AGRONOMICA
ACADEMIAE SCIENTIARUM HUNGARICAE

TOMUS XXIX FASCICULI 3—4

AKADÉMIAI KIADÓ, BUDAPEST
1980

ACTA AGRON. HUNG.

ACTA AGRONOMICA

A MAGYAR TUDOMÁNYOS AKADÉMIA
AGRÁRTUDOMÁNYI KÖZLEMÉNYEI

A szerkesztő bizottság elnöke:
RAJKI SÁNDOR

Szerkesztő:
PÁL GYULA

SZERKESZTŐSÉG ÉS KIADÓHIVATAL: 1054 BUDAPEST, ALKOTMÁNY UTCA 21.

Az Acta Agronomica angol nyelven közöl értekezéseket az agrártudomány tárgyköréből, főképpen a mezőgazdasági alapkutatások területéről.

Az Acta Agronomica változó terjedelmű füzetekben jelenik meg, több füzet alkot egy kötetet.

A közlésre szánt kéziratok a következő címre küldendők:

Acta Agronomica
2462 Martonvásár, Postafiók 19.

Ugyanerre a címre küldendő minden szerkesztőségi és kiadóhivatali levelezés.

Megrendelhető a belföld számára az Akadémiai Kiadónál (1363 Budapest, Pf. 24. Bankszámla 215-11488), a külföld számára pedig a „Kultura" Külkereskedelmi Vállalatnál (1389 Budapest 62, P.O.B. 149. Bankszámla: 218-10-990) vagy annak külföldi képviseleteinél.

The Acta Agronomica publishes papers in English on agronomical subjects, mostly on basic research.

The Acta Agronomica appears in one volume (four issues) a year.

Manuscripts should be addressed to:

Acta Agronomica
H-2462 Martonvásár, Postafiók 19.

Orders may be placed with "Kultura" Foreign Trading Company (H-1389 Budapest 62, P.O.B. 149, Bank Account No. 218-10-990) or its representatives abroad.

ACTA AGRONOMICA
ACADEMIAE SCIENTIARUM HUNGARICAE

TOMUS XXIX

AKADÉMIAI KIADÓ, BUDAPEST
1980

ACTA AGRON. HUNG.

ACTA AGRONOMICA

TOMUS XXIX

INDEX

Fasc. 1—2.

VARIA

"AS I SEE IT..."

FORUM

LECTIONES

RECENSIONES

AUCTORES

Fasc. 3–4.

VARIA

FORUM

CHRONICA

LECTIONES

RECENSIONES

AUCTORES

Acta Agronomica Academiae Scientiarum Hungaricae, Tomus 29 (3—4), pp. 247—263 (1980)

IMPROVING TETRAPLOID MONOGERM SUGAR BEET POPULATIONS AND THEIR HYBRIDS FOR SEED CHARACTERS, ROOT YIELD AND TECHNICAL VALUE

I. SELECTION FOR DIFFERENT SEED BEARER BIOTYPES

By

M. A. Farag, L. Magassy

RESEARCH INSTITUTE FOR SUGAR BEET, SOPRONHORPÁCS

Eight seed bearer biotypes were selected from the tetraploid monogerm population as follows: I. Early flowering pine tree, II. Mid-season pine tree, III. Late flowering pine tree, IV. Early flowering bush, V. Mid-season bush, VI. Late flowering bush, VII. Semi-vegetative pine tree, VIII. Semi-vegetative bush. The seed properties, root yield and technical value of the biotypes were investigated. The tetraploid monogerm biotypes were crossed with the diploid multigerm pollinator and the hybrids were also tested for seed characters, root yield and technical value. The mid-season biotypes had the highest seed production compared with the early and late flowering biotypes. The bush biotypes gave higher seed yields than the pine tree biotypes in every stage of flowering. Significant differences could be identified in the seed properties, root yield and technical value of the different biotypes. The germination, fruit weight, fruit size, root yield, sugar content and extractable sugar production increased significantly in the early flowering biotypes, while the monogermity decreased gradually in mid-season and early flowering biotypes. A strong relationship was observed in seed characters, root yield and technical value between the parents and hybrids of the biotypes. The effect of flowering times (early, mid-season and late) was higher than the influence of the seed stalk formation (pine tree and bush). The highest triploid percentage was found in the hybrids of mid-season biotypes and it decreased in hybrids of early and late flowering biotypes. The results show clearly that the selection for different seed bearer biotypes has an appreciable effect in the tetraploid monogerm population. The separation of the different biotypes according to flowering times involves some separation of the different genotypes.

Introduction

Polyploidy is of great importance for sugar beet breeding. Triploidy apparently represents the optimum level of polyploidy because triploids have larger roots and also more sugar yield per unit area than diploids. Triploid sugar beet hybrids are developed either by crossing cytoplasmically male-sterile diploids with tetraploid lines or by crossing a tetraploid seed parent with a diploid. Triploid offspring such as these combine the advantages of both hybrid vigour and polyploid vigour (Magassy 1960, Masutani—Nakajima 1970).

The monogerm character (one flower and only one germ for each fruit) should prove to be a great advance in sugar beet breeding and production (Savitsky 1950, 1952). Multigerm beet (two or more flowers or possible germs for each flower cluster) needed considerable labour for thinning the excessive number of seedlings. The development of monogerm commercial varieties will permit the accurate spacing of sugar beet seeds by mechanical equipment providing an opportunity for the growers to decrease the amount of labour needed for thinning. In the production of hybrids, the monogerm line may be used only as the seed-producing parent. The pollinator may be either multigerm diploid or tetraploid depending on the type of hybrids.

At present various types of monogerm hybrids are produced as follows (Magassy 1975): 1. Diploid hybrids. Diploid male-sterile monogerm × diploid multigerm fertile. 2. Triploid hybrids. Diploid male-sterile monogerm × tetraploid multigerm fertile. 3. Tetra-tri hybrids. Tetraploid monogerm fertile × diploid multigerm fertile.

In recent years, there have been reports on various aspects of the possibility of producing triploid hybrids by using the tetraploid male-sterile monogerm as the seed-producing parent (Lahousse 1976, Bosemark 1977).

The tetraploid monogerm fertile populations are used on a commercial scale in Hungary as the seed parent for the production of BETA poli M/102 and BETA Monopoli N. 1. varieties (tetra-tri hybrids) by crossing with a diploid multigerm fertile. The hybridization is not complete on a tetraploid monogerm fertile parent but the proportion of triploid seeds is higher than normally expected because the pollen of the diploid grows faster in tetraploid styles than does the pollen of the tetraploid. Several previous results showed the advantages of triploids grown on tetraploid plants over triploids produced on diploids (Szota 1971, Fitzgerald 1975).

Polyploidization in beet causes morphological and physiological changes compared with the diploid. Generally, the tetraploid beets have larger cells, leaves, flowers and seeds or other plant parts than their diploid counterparts and for this reason are interesting and useful, despite their lower fertility and generally slower rate of development. Tetraploid beets have reduced fertility and produce fewer seeds than do the corresponding diploids (Abegg 1940, Rasmusson—Levan 1939, Ernould 1946, Hosokawa *et al.* 1952, Sedlmayr 1955, Speckmann—Kloen 1956, Beysel 1957, Magassy 1962b).

Reduced fertility is an unfavourable effect of polyploidy. The tetraploid seed has a lower germination rate than the diploid (Feltz 1953, Bartl *et al.* 1957, Csapody 1961a, Jassem 1961, Magassy 1961, 1962a). In comparison with the corresponding diploids, tetraploids were later maturing and had a longer flowering period (Abegg *et al.* 1946, Zagrekava—Semyarykhina 1969). On the other hand, the weight of 1000 clusters was larger in the tetraploid than in the diploid counterpart (Csapody 1961a, Magassy 1961).

Since the polyploid varieties are commonly used, it was very important to study the possibilities of improving their seed characters, especially for monogerm varieties, which also show reduced fertility. In modern agriculture, high quality seed is of inestimable value.

The monocarpic polyploid populations are of less value compared to multigerm populations as regards the vegetative and reproductive characters: germination, seed uniformity, time of maturity, flowering period and the appearance of various undesirable biotypes (CSAPODY 1961b, 1970, 1972, RÖSTEL 1966, 1972c, BUCKS 1970, SHIVYREVA 1973).

In the improvement of the monogerm polyploid sugar beet varieties the study of the seed bearer biotypes plays an important role. The breeding and selection procedure on the basis of biotypes of seed plants has not yet been elaborated, so it is not widely known.

In the monogerm populations many biotypes of the mother beets were found to differ in morphological and physiological properties (size of fruit, flowering time, maturation, germination, degree of monogermity, vitality and initial rate of growth). Selection for good morphological characters and high germination was of importance in improving seed quality and the production of root and sugar (KOTUKOV 1958, MANZELEJ 1958, NEGOVSKY—TKACHENKO 1959, BEREZKO 1962, BUCKS 1970, CSAPODY 1970, BALAN—MUDRIK 1972, RÖSTEL 1972a, 1972b, EFREMOV—BAUM 1973, SHIVYREVA 1973, ABUGALIEV—NABOKIKH 1975, BAMBURA *et al.* 1975).

RÖSTEL (1975) reported that selection for high germination capacity in the 4x and 2x parents led to no improvement, but indirect selection for early and uniform maturity of the seed plants, for round fruits, for closely set fruits and for good seed plant type, was more effective. BOLELOVA (1968) reported that cytological testing and the rejection of plants with abnormal mitosis eliminates undesirable biotypes.

The early maturing biotypes have the highest seed producing capacity, 1000 fruit weight and germination (EFREMOV—ORLOVSKY 1965, ARKHANGELSKY—AL-GAZAL 1971, ARKHANGELSKY—BUKA 1972, KOZLOVSKY—ZABRODSKAYA 1972, RÖSTEL 1972b, ZABRODSKAYA—GRIB 1976). In the monogerm tetraploid the group of mid-season seed plants was the most numerous (50%) giving the highest yield of seeds with the greatest 1000 fruit weight (GAEVSKAYA 1972).

Considerable differences in root and sugar yield were observed between the progenies of different biotypes of monogerm beets. Most of the results showed the high yielding capacity and sugar production of the early biotypes (KOTUKOV 1958, USTIMENKO 1963, EFREMOV—ORLOVSKY 1965, KOZLOVSKY—ZABRODSKAYA 1972, RÖSTEL 1972b). On the other hand NEGOVSKY—TKACHENKO (1959) found that the mid-season biotypes had higher root and sugar yield than the early and late maturing biotypes.

The monogerm character is produced by one recessive basic gene in homozygous mm condition. Some other genes may modify the manifestation of the gene m causing the appearence of a few double-germ fruits on the monogerm plants (SAVITSKY 1952). KNAPP (1967) observed that monocarpy was recessive and governed by a single gene in the American, and by more than one gene in the Russian and German material.

The heritability of weight of fruits and germs in different monogerm populations appears to be low, but selection is effective for increased weight of monogerm fruits because of the heterogeneity of the genes controlling the weight of fruits (SAVITSKY—SAVITSKY 1965). SEDLMAYR (1962) found that speed of germination is highly heritable and that it is controlled mainly by the maternal parts of the seed. Dominance had no significance in inheritance.

The bigerm forms existing in populations of monogerm sugar beet are heterozygous for monogermity. The bigerm character is affected by modifiers (LOBODIN 1972). The presence of undesirable bigerm seed balls increases the germination rate and vitality of the seeds and also increases the root yield of the first year of growth (KOLOMIEC 1966, RÖSTEL 1972b). To improve the monogerm sugar beet varieties, all the multigerm types in the monogerm populations must be removed (BORDONOS 1965, LOBODIN 1973).

This study includes a comparison between different breeding methods and seed treatments to improve the seed quality and sugar production of monogerm tetraploid populations and hybrids.

Materials and Methods

In the season of 1974 eight seed bearer biotypes were selected from the tetraploid monogerm population M. 914, which is the seed parent of the commercial variety BETA poli M/102, as follows:

A) "Pine tree" biotype, characterized by developing one seed stalk on the mother beet (Fig. 1). From this biotype, selection was carried out three times during the flowering process (early, mid-season and late).
   I. Early flowering pine tree (at the very beginning of flowering).
   II. Mid-season pine tree (about the middle of flowering).
   III. Late flowering pine tree (at the end of flowering).

B) "Bush" biotype, characterized by developing a group of seed stalks on the mother beet (Fig. 2). From this biotype, the same selection was made as in the pine tree biotype according to the flowering time.
   IV. Early flowering bush.
   V. Mid-season bush.
   VI. Late flowering bush.

C) "Semi-vegetative" biotype. The reproductive growth of this biotype is very poor and the flowering time is very late. This biotype has no economic value since the late blooming flowers rarely produce mature seeds capable of germinating. Two types of the vegetative biotype were selected for the growth habit of seed stalks:
   VII. Semi-vegetative pine tree (Fig. 3).
   VIII. Semi-vegetative bush (Fig. 4).

In 1975, seeds of the different biotypes (I—VIII) were investigated for seed yield, germination, 1000 fruit weight, monogermity and seed grading according to the diameters of the fruits.

In 1975, biotypes I—VI were investigated for root yield and technical value in a randomized complete block with six replications. Because of the very low seed yield and vitality of the semi-vegetative biotypes, VII and VIII were not included in this experiment.

Fig. 1. Pine tree biotype

Fig. 2. Bush biotype

In 1976, the tetraploid monogerm biotypes I—VI were crossed with the diploid multigerm BETA E.III, which is the pollinator for the production of the commercial variety BETA poli M/102. Hybrid seeds produced on tetraploid monogerm biotypes I—VI were tested for: germination, 1000 fruit weight, monogermity, frequency of different seed sizes and frequency of triploids and tetraploids in the different seed sizes.

In 1977, hybrid seeds produced on tetraploid monogerm biotypes I—VI were tested for root yield and technical value in three locations (Sopronhorpács, Martfű and Mezőhegyes). The experimental design was a randomized complete block with six replications. In the field trials every plot included three rows, each row was 10 meters long, and the distance was 45 cm between rows and 20 cm between plants.

For the cytological analyses (counting of chromosomes), 1000 seeds were wrapped in moist filter paper and germinated at 25°C for each treatment. The root tips were fixed in Carnoy and stained with aceto-carmine.

For the determination of the different seed sizes, the hybrid seeds were graded by slot hole screens for different diameters. The laboratory tests for the seed quality (germination, 1000 fruit weight, monogermity) were carried out in five replications. In 1975, the extractable sugar production was calculated as follows:

$$\text{root yield} \cdot \frac{\text{polarization} - (1.61\ \text{ash} + 2.35)}{100}$$

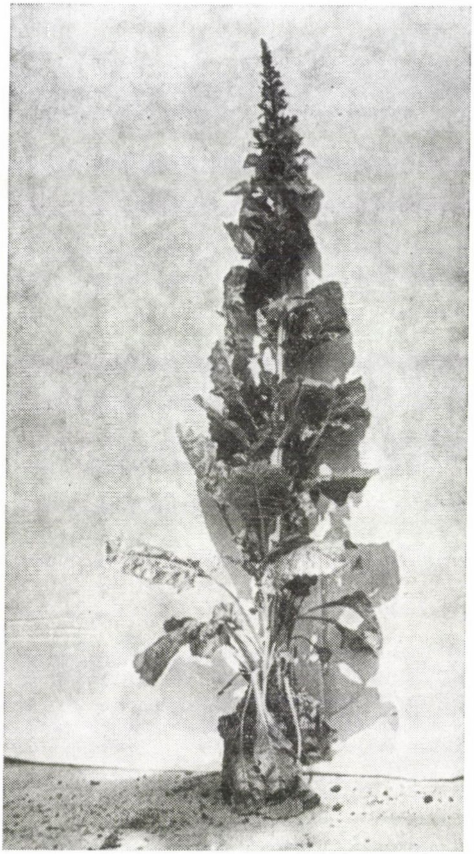


Fig. 3. Semi-vegetative pine tree biotype

while in 1977 it was equal to:

$$\text{root yield} \cdot \frac{\text{corrected sugar content}}{100}$$

$$\text{corrected sugar content} = \text{polarization} - [0.343 \cdot (K + Na) + 0.094 \cdot \text{amino-N} + 0.29]$$

Results

Seed characters of tetraploid monogerm biotypes. Great significant differences were observed among the various biotypes for the seed properties (Table 1). Considering the biotypes according to the flowering time, the mid-season biotypes (pine tree and bush) had the highest seed production. On the other hand, the bush biotypes usually had higher seed yield than pine tree biotypes for each stage of the flowering time. The seed yield of the very late semi-vegetative biotypes was very low.

Fig. 4. Semi-vegetative bush biotype

The weight of 1000 fruits (g) increased for early flowering biotypes and decreased for the late flowering biotypes. The pine tree biotypes showed higher 1000 fruit weight than the bush biotypes for each flowering time. The very late semi-vegetative biotypes had higher 1000 fruit weight than the late flowering pine tree and bush biotypes. This was due to the low seed productivity of the semi-vegetative biotypes. The germination percentage increased for early flowering biotypes and decreased gradually for mid-season and late flowering biotypes. The germination of the semi-vegetative biotypes was very poor. Slight differences were found between the pine tree and bush biotypes in the same flowering time.

A complete monogermity (100%) was observed in the late flowering pine tree, bush and semi-vegetative biotypes. The monogermity gradually decreased for the mid-season and early flowering biotypes. Very slight differences were observed if at all, between pine tree and bush biotypes within the same flowering stage.

All the biotypes have great variation in their fruit diameter, especially fruits of the early biotypes. The flowering time (early, mid-season and late) has more influence on the fruit size than the seed stalk formation (pine tree and bush) within the same flowering time. In general, a high percentage of large fruit size could be found in the early flowering biotypes, while a lot of small fruits were found in the late biotypes. Large fruits (with a diameter of more than 5 mm) could be found only in the early flowering and mid-season biotypes, while small fruits (with a diameter of 2.0—2.5 mm) were observed in all the different biotypes.

Root yield and technical value of the tetraploid monogerm biotypes. The results for yield of beets (Table 3) showed a progressive improvement in root yield due to selection for the flowering time. The root yields of early flowering and mid-season biotypes were significantly higher than the yields obtained on the late biotypes. There were no significant differences in the yield of pine tree and bush biotypes within the same flowering time. Comparing the root yield of different biotypes with the original tetraploid monogerm population (M.914), it was observed that the root yield of M.914 was similar to the yield of mid-season biotypes, as a result of the fact that the highest number of seed bearers was found in the mid-season biotypes in the population M.914.

The early flowering and mid-season biotypes gave the highest sugar content. The late flowering biotypes produced a significant reduction in sugar content. The conductometric ash percentage increased for the late flowering biotypes.

The extractable sugar production of the early flowering and mid-season biotypes was significantly higher than the sugar production of late flowering biotypes. No significant differences could be identified among the biotypes within the same time of flowering.

Seed characters of hybrids produced on the progeny of the different tetraploid monogerm biotypes by crossing with the diploid multigerm pollinator

In Table 4 significant differences among the hybrids of the different biotypes differing in flowering time can be seen. The flowering time of the biotypes has a higher influence on seed properties than the seed stalk formation.

The early flowering biotypes gave the highest 1000 fruit weight. The value of this character decreased gradually for mid-season and late flowering biotypes, though the results showed significant differences for 1000 fruit weight between hybrids produced on the progeny of pine tree and bush biotypes which flowered at the same time. These differences can be considered to be very slight in comparison with the biotypes of the different flowering times.

Comparing these results with the weight of 1000 fruits of the parents (Table 1), a very strong relationship could be observed between the parents

Table 1

Seed yield, weight of 1000 fruits, germination and monogermity of the tetraploid monogerm biotypes

Biotypes	Seed yield, g	Weight of 1000 fruits, g	Germination	Monogermity
			%	
I. Early flowering pine tree	128.6	23.10	84.6	89.2
II. Mid-season pine tree	159.8	20.75	78.2	95.4
III. Late flowering pine tree	79.2	17.69	66.4	100.0
IV. Early flowering bush	180.4	21.99	86.0	90.8
V. Mid-season bush	234.0	19.42	79.8	95.6
VI. Late flowering bush	127.2	17.03	67.6	100.0
VII. Semi-vegetative pine tree	20.2	19.70	31.0	100.0
VIII. Semi-vegetative bush	26.4	19.47	30.2	100.0
LSD 5% ±	8.49	0.35	1.80	1.0

and the hybrids in this respect. Differences in germination were significant for the flowering times, but not for the seed stalk formation (pine tree and bush) within the same flowering period. The highest germination was obtained on the hybrids of early flowering biotypes and the germination percentage decreased gradually in the mid-season and in the late flowering biotypes. A similar tendency was observed for the germination in the parents of the hybrids (Table 1).

The early flowering biotypes produced the lowest monogermity and this increased gradually in hybrids of the mid-season and late flowering biotypes. The results indicated that the monogermity decreased in all the hybrids of different biotypes in comparison with the parents.

Table 5 showed large differences in fruit size among the hybrids of the different biotypes as regards the flowering time, while slight differences could be found among the hybrids of biotypes differing in the seed stalk formation (pine tree and bush) within the same flowering time. A high percentage of large fruit sizes was observed in hybrids of early flowering biotypes and this greatly decreased in the hybrids of the late biotypes.

Small fruits (diameter 2.0—2.5 mm) were found in all the hybrids of the different biotypes. A relatively higher uniformity of fruit size was produced in the hybrids of the late flowering biotypes than in the hybrids of early flowering and mid-season biotypes. This may have been due to the shorter flowering and maturity period of the late flowering biotypes.

A strong relationship was found in the fruit sizes between the parents and hybrids of the biotypes (Tables 2 and 5).

The percentage of triploids increased in the hybrids of mid-season biotypes and gradually decreased in the hybrids of the late flowering and early

Table 2

Fruit size distribution by diameter for tetraploid monogerm biotypes

Biotypes	2.0—2.5	2.5—3.0	3.0—3.5	3.5—4.0	4.0—5.0	5
	mm, %					
I. Early flowering pine tree	3	5	12	19	53	8
II. Mid-season pine tree	4	12	20	34	28	2
III. Late flowering pine tree	5	14	56	24	1	—
IV. Early flowering bush	3	9	13	27	42	6
V. Mid-season bush	4	13	27	32	22	2
VI. Late flowering bush	6	17	64	13	—	—
Mean	4.00	11.50	32.50	24.67	24.33	3.00

Table 3

Root yield and technical value of tetraploid monogerm biotypes

Location: Sopronhorpács, 1975

Biotypes	Root yield		Sugar content		Conductometric ash content		Extractable sugar production	
	t/ha	rel.%	%	rel.%	%	rel.%	t/ha	rel.%
I. Early flowering pine tree	45.52	101.99	14.68	100.34	0.525	100.38	5.222	102.17
II. Mid-season pine tree	44.67	100.09	14.63	100.00	0.533	101.91	5.104	99.86
III. Late flowering pine tree	42.21	94.58	14.22	97.20	0.542	103.63	4.644	90.86
IV. Early flowering bush	45.36	101.64	14.55	99.45	0.533	101.91	5.148	100.72
V. Mid-season bush	44.84	100.47	14.70	100.48	0.527	100.76	5.156	100.88
VI. Late flowering bush	42.66	95.50	14.33	97.95	0.545	104.21	4.733	92.60
M.914.	44.63	100.00	14.63	100.00	0.523	100.00	5.111	100.00
LSD 5% ±	1.92	4.30	0.29	1.98	0.022	4.21	0.253	4.95

Table 4

Seed characteristics of hybrids produced on the progeny of tetraploid monogerm biotypes

Hybrids produced on the progeny of different biotypes	Weight of 1000 fruits, g	Germination	Monogermity
		%	
I. Early flowering pine tree	22.99	83.6	84.6
II. Mid-season pine tree	20.30	82.4	93.2
III. Late flowering pine tree	16.55	77.8	96.8
IV. Early flowering bush	22.39	83.8	85.7
V. Mid-season bush	19.68	82.6	94.1
VI. Late flowering bush	15.71	77.2	97.6
LSD 5% ±	0.48	1.29	0.66

Table 5

Percentages of triploids (3x) and tetraploids (4x) in different fruit sizes of hybrids produced on the progeny of tetraploid monogerm biotypes

Hybrids produced on the progeny of different biotypes	2.0—2.5 mm		2.5—3.0 mm		3.0—3.5 mm		3.5—4.0 mm		4.0—5.0 mm		5 mm		Total	
	3x	4x	3x	4x	3x	4x	3x	4x	3x	4x	3x	4x	3x	4x
I. Early flowering pine tree	5	—	5	2	12	2	14	2	35	15	2	6	73	27
II. Mid-season pine tree	3	2	7	3	20	—	46	1	13	3	—	2	89	11
III. Late flowering pine tree	2	5	7	10	50	7	15	2	1	1	—	—	75	25
IV. Early flowering bush	4	1	5	1	11	1	21	2	30	15	2	7	73	27
V. Mid-season bush	4	2	10	3	18	—	45	—	13	2	1	2	91	9
VI. Late flowering bush	2	6	9	11	52	5	13	—	—	2	—	—	76	24
Mean	33.3	2.67	7.17	5.0	27.17	2.5	25.67	1.17	15.33	6.33	0.83	2.83	79.5	20.5

Table 6

Root yield and technical value of hybrids produced on the progeny of tetraploid monogerm biotypes
Location: Sopronhorpács, 1977

Hybrids produced on the progeny of different biotypes	Root yield		Sugar content		Potassium		Sodium		Amino-nitrogen		Corrected sugar content		Extractable sugar production	
	t/ha	rel.%	%	rel.%	meq/100 g beet	rel.%	meq/100 g beet	rel.%	meq/100 g beet	rel.%	%	rel.%	t/ha	rel.%
I. Early flowering pine tree	38.30	106.60	18.04	102.44	5.42	98.54	0.70	93.33	3.14	101.95	15.33	101.86	5.881	108.91
II. Mid-season pine tree	35.71	99.39	17.80	101.08	5.36	97.45	0.72	96.00	3.06	93.35	15.14	100.60	5.407	100.13
III. Late flowering pine tree	33.33	92.76	17.77	100.91	5.59	101.64	0.72	96.00	3.50	113.64	14.99	99.60	5.000	92.59
IV. Early flowering bush	37.85	105.34	17.82	101.19	5.39	98.00	0.74	98.67	2.87	93.18	15.16	100.73	5.733	106.17
V. Mid-season bush	36.37	101.22	17.79	101.02	5.50	100.00	0.73	97.33	3.01	97.73	15.08	100.20	5.481	101.50
VI. Late flowering bush	34.34	95.57	17.77	100.91	5.46	99.27	0.75	100.00	2.99	97.08	14.91	99.07	5.119	94.80
BETA poli M/102	35.93	100.00	17.61	100.00	5.50	100.00	0.75	100.00	3.08	100.00	15.05	100.00	5.400	100.00
LSD 5% ±	1.71	4.76	0.42	2.39	0.40	7.27	0.08	10.67	0.49	15.91	0.40	2.66	0.273	5.06

flowering biotypes. Most of the large fruits of early flowering biotypes were tetraploids. Triploids decreased in the small fruit diameters (2.0—2.5 and 2.5—3.0 mm) of the late flowering biotypes while tetraploids greatly increased. With regard to the hybrids of mid-season biotypes, tetraploids were obtained to approximately the same extent in each of the small and large fruit sizes. The flowering periods only have an influence on the hybridization (percentage of triploids).

Root yield and technical value of the hybrids produced on the progeny of the different tetraploid monogerm biotypes by crossing with the diploid multigerm pollinator. Significant differences were observed in the root yield and extractable sugar production of the hybrids of different biotypes in all three locations (Sopronhorpács, Martfű and Mezőhegyes) (Tables 6, 7 and 8).

Hybrids of the early flowering biotypes gave the highest root yield and extractable sugar production and these decreased gradually in the hybrids of mid-season and late flowering biotypes. No significant differences could be found between the hybrids of pine tree and bush biotypes which flowered at the same time.

The results showed no significant differences among the hybrids of the different biotypes in sugar content, though the sugar content slightly decreased in the hybrids of the late flowering biotypes compared with the others. No clear differences were observed for K, Na and amino-nitrogen content among the different hybrids.

The yield and technical value of the hybrids of mid-season biotypes were similar to the commercial variety BETA poli M/102 (control). The mid-season biotypes were the most numerous in the population and were considered to be the average of the population. Therefore a similarity in root yield and technical value was expected for the hybrids of the mid-season biotypes and the control.

Discussion

The advantages of polyploidy in sugar beet depend on a higher accumulation of the genes determining the yield and on a higher degree of heterozygosity. Sugar beet is naturally cross fertilized and in naturally occurring populations individual plants are highly heterozygous. Tetraploid monogerm populations have advantages for practical breeding. A high degree of genetic heterogeneity could also be found in tetraploid monogerm sugar beet populations.

In monogerm populations different seed bearer biotypes were found, especially in the tetraploids. Undesirable morphological biotypes were also observed in the monogerm population. The tetraploids were late in maturity and had a longer flowering period than the diploids. Because of the great

Table 7

Root yield and technical value of hybrids produced on the progeny of tetraploid monogerm biotypes
Location: Martfű, 1977

Hybrids produced on the progeny of different biotypes	Root yield		Sugar content		Potassium		Sodium		Amino-nitrogen		Corrected sugar content		Extractable sugar production	
	t/ha	rel.%	%	rel.%	meq/100 g beet	rel.%	meq/100 g beet	rel.%	meq/100 g beet	rel.%	%	rel.%	t/ha	rel.%
I. Early flowering pine tree	44.54	106.56	17.03	100.18	6.84	93.57	3.36	88.42	4.85	85.09	12.79	103.48	5.704	110.33
II. Mid-season pine tree	42.85	102.51	16.97	99.82	7.00	95.76	4.37	115.00	6.42	112.63	12.17	98.46	5.215	100.87
III. Late flowering pine tree	38.58	92.30	16.75	98.53	6.87	93.98	3.32	87.37	5.89	103.33	12.41	100.40	4.711	91.12
IV. Early flowering bush	44.81	107.20	17.00	100.00	7.11	97.26	3.40	89.47	5.49	96.32	12.59	101.86	5.644	109.17
V. Mid-season bush	41.84	100.10	17.10	100.59	6.92	94.66	3.82	100.53	5.48	96.14	12.62	102.10	5.281	102.15
VI. Late flowering bush	38.44	91.96	16.80	98.82	7.14	97.67	3.56	93.68	5.91	103.68	12.28	99.35	4.719	91.28
BETA poli M/102	41.80	100.00	17.00	100.00	7.31	100.00	3.80	100.00	5.70	100.00	12.36	100.00	5.170	100.00
LSD 5% ±	2.36	5.64	0.38	2.24	0.53	7.25	1.24	32.63	0.87	15.26	0.72	5.83	0.390	7.54

Table 8

Root yield and technical value of hybrids produced on the progeny of tetraploid monogerm biotypes
Location: Mezőhegyes, 1977

Hybrids produced on the progeny of different biotypes	Root yield		Sugar content		Potassium		Sodium		Amino-nitrogen		Corrected sugar content		Extractable sugar production	
	t/ha	rel.%	%	rel.%	meq/100 g beet	rel.%	meq/100 g beet	rel.%	meq/100 g beet	rel.%	%	rel.%	t/ha	rel.%
I. Early flowering pine tree	40.24	101.98	16.08	100.37	7.12	100.00	3.41	98.84	2.47	75.07	11.95	101.36	4.807	103.33
II. Mid-season pine tree	38.76	98.23	16.30	101.75	7.60	106.74	3.52	102.03	3.00	91.19	11.88	100.76	4.607	99.03
III. Late flowering pine tree	35.87	90.90	15.92	99.38	6.43	90.31	3.50	101.45	2.92	88.75	11.95	101.36	4.274	91.87
IV. Early flowering bush	40.48	102.58	16.08	100.37	7.24	101.68	3.66	106.09	3.12	94.83	11.76	99.75	4.763	102.39
V. Mid-season bush	38.89	98.56	16.18	101.00	7.31	102.67	3.68	106.67	2.94	89.36	11.85	100.51	4.607	99.03
VI. Late flowering bush	36.00	91.23	16.07	100.31	7.17	100.70	3.24	93.91	2.48	75.38	11.97	101.53	4.311	92.67
BETA poli M/102	39.46	100.00	16.02	100.00	7.12	100.00	3.45	100.00	3.29	100.00	11.79	100.00	4.652	100.00
LSD 5% ±	2.64	6.69	0.26	1.62	1.02	14.33	0.62	17.97	0.50	15.20	0.71	6.02	0.345	7.42

differences in flowering time for different biotypes in a monogerm population, many results have been obtained for the effect of flowering time on seed quality (RÖSTEL 1972a, SHIVYREVA 1973, BAMBURA *et al.* 1975).

It was found that the rate of semi-vegetative biotypes sometimes reached 25—30% in polyploid monogerm populations (CSAPODY 1970). The appearance of semi-vegetative biotypes decreases the yield and seed quality to a great extent in monogerm tetraploid populations, because these plants produce very few seeds and these are of poor quality.

The biotypes which were selected from the monogerm tetraploid population showed great differences in yield and seed characters. The study of seed bearer biotypes plays an important role in the improvement of monogerm varieties.

Our results also showed significant differences in seed characters, root yield and technical value of the biotypes. The weight of 1000 fruits, germination, fruit size, root yield, sugar content and extractable sugar production increased significantly for the early flowering biotype, while monogermity decreased in the early flowering biotypes and increased significantly in seeds of the late biotype. Similar results were observed by RÖSTEL (1972b), KOZLOVSKY—ZABRODSKAYA (1972), ARKHANGELSKY—BUKA (1972), GAEVSKAYA (1972) and ZABRODSKAYA—GRIB (1976).

The results show that selection for different seed bearer biotypes is very effective in the tetraploid monogerm population M.914. The "bush" seed stalk formation gave higher seed yield than the "pine tree" formation, but the seed characters of these biotypes were similar in each flowering time. It can be concluded that the effect of flowering times (early, mid-season and late) was greater than the influence of the seed stalk formation (pine tree and bush).

A very strong relation was observed with respect to seed characters, yield and technical value between the parents and hybrids of the biotypes.

The properties of the hybrid seed produced on the progeny of the different biotypes showed a strong relation with the parents. The results for 1000 fruit weight in the parents and hybrids showed that the early biotypes which had large fruits also produced large fruits in the hybrids of their progeny. On the other hand, the late biotypes which had small fruits also produced small fruits in their hybrids. Similar results were observed by DOXTATOR—HELMERICK (1962) in diploid monogerm material.

Significant differences were found in the germination, especially for the flowering times. The tendency of this property was similar for the parents and their hybrids. Breeding should aim to improve the germination of the tetraploid monogerms by selecting early flowering biotypes.

A strong relationship could be found in monogermity between the parents and their hybrids. The results indicated that without selection for monogermity, the percentage of multigerm seeds increased in the progenies.

A great variation and large differences were observed in fruit diameters of biotypes and their hybrids too. A strong relation could be determined in fruit sizes between the parents and their hybrids.

The highest triploid percentage was found in the hybrids of mid-season biotypes and it decreased in the hybrids of early and late flowering biotypes. On the other hand, the tetraploids greatly increased in the large fruits of early flowering and in the small fruit diameters of the late flowering biotypes. These results indicate that the progeny of the mid-season biotypes flowered approximately at the same time as the diploid multigerm pollinator. The progeny of the early biotypes began to flower earlier than the diploid multigerm pollinator. At the end of the flowering season there was no haploid pollen for the hybridization of the late flowering biotypes because the diploid multigerm pollinator had a shorter flowering period than the tetraploid monogerm partner. Our results agreed with the opinion of FÜRSTE (1958), SCHNEIDER (1960) and SEDLMAYR (1961). They indicate that the frequency of triploids is at a maximum in the medium sized seed-balls and decreases in the largest and smallest seed-balls.

The early flowering biotypes gave the highest root yield and extractable sugar production. The yield and technical value of mid-season biotypes were similar to the commercial control variety BETA poli M/102. There were significant differences in the sugar content among the biotypes but the differences were not significant in their hybrids.

References

ABEGG, F. A. (1940): The induction of polyploid in *Beta vulgaris* L. by cholchicine treatment. Proc. Amer. Soc. Sugar Beet Technol., **2**, 118—119.

ABEGG, F. A.—STEWART, D.—COONS, G. H. (1946): Further studies on sugar beet autotetraploids. Proc. Amer. Soc. Sugar Beet Technol., **4**, 223—229.

ABUGALIEV, I. A.—NABOKIKH, K. I. (1975): Morphological characters and seed yield in sugar beet seed plants. Kazakhsk. NII. Zemledelija, **11**, 199—205.

ARKHANGELSKY, N. S.—AL-GAZAL, R. K. (1971): Seed production of biotypes of monogerm sugar beet. Izvestija Timirjazevskoj Selskohozjajstvennoj Akademii, Moskva, **5**, 31—41.

ARKHANGELSKY, N. S.—BUKA, S. S. (1972): The productivity of varieties and biotypes of mangel and sugar beet. Doklady TSKha No. 180, II, 55—59.

BALAN, V. N.—MUDRIK, V. I. (1972): Results of production tests of roguing in monogerm sugar beet plantings. Osnovn. vyvody nauch. issled. rabot. VNII. 151—152.

BAMBURA, A. M.—BIDULYA, E. G.—CHERNATA, D. M.—KORBUT, G. M. (1975): Growing the seeds of polyhybrids separately by components. Sacharnaja Svekla, **11**, 37—39.

BARTL, K.—CURTH, P.—FISCHER, H. E.—SCHNEIDER, H. (1957): Untersuchungen über die Keimfähigkeit von polyploidem Zuckerrübensaatgut. Zucker, **10**, 142—147; 163—168.

BEREZKO, S. T. (1962): Biological characteristics of tetraploid monogerm sugar beet. Sb. nauchn. rabot Belocerkovsk Nr. 2, 65—74.

BEYSEL, D. (1957): Assimilations- und Atmungsmessungen an diploiden und polyploiden Zuckerrüben. Züchter, **27**, 261—272.

BOLELOVA, Z. A. (1968): Biological characteristics of seeds of tetraploid sugar beet and how to improve their sowing qualities. Rastenievodstvo, selekcija i lesovodstva, **1**, 141—148.

BORDONOS, M. G. (1964): How to stabilize the character of monogermity in induced varieties? Sacharnaja Svekla, **3**, 36—37.

BOSEMARK, N. O. (1977): Use of tetraploid monogerm male steriles in triploid hybrid-seed production. I.I.R.B. 40th Winter Congress Proc. 271—287.

BUCKS, A. (1970): Möglichkeiten zur Verbesserung der Saatgutqualität monokarper tetraploider Zuckerrüben durch züchterische und aufbereitungstechnische Massnahmen. Thesis, Martin-Luther-Universität, Halle-Wittenberg, 78.

CSAPODY, GY. (1961a): Adatok a különböző ploiditású cukorrépamag csírázásbiológiájához (Some biological data on the germination of sugar beet seeds with different degrees of ploidy). Növénynem. és Növényterm. Kut. Int. Közl. Sopronhorpács, **1,** 149—176.

CSAPODY, M. (1961b): Monogerm répanemesítés (The breeding of monogerm beets). Növénynem. és Növényterm. Kut. Int. Közl. Sopronhorpács, **1,** 95—113.

CSAPODY, M. (1970): Monokarp poliploidok (Monogerm polyploids). Növénynem. és Növényterm. Kut. Int. Közl. Sopronhorpács, **6,** 281—285.

CSAPODY, M. (1972): Monokarp cukorrépafajták minőségének javítása nemesítéssel (Improvement of the quality in monogerm sugar beets by selection). Répaterm. Kut. Int. Közl. Sopronhorpács, **7,** 59—72.

DOXTATOR, C. W.—HELMERICK, R. H. (1962): Selection for seed size in monogerm varieties. J. Amer. Soc. Sugar Beet Technol., **12/3,** 268—272.

EFREMOV, A. E.—ORLOVSKY, N. I. (1965): Einfluss der positiven Selektion auf die Saatgutqualität und Leistungsfähigkeit monokarper Zuckerrüben. Tezisu naucsno-proizvodztvennoj konferencii, Kiev, 204—206.

EFREMOV, A. E.—BAUM, O. G. (1973): Negative selection and seed quality of polyploid sugar beet. Sacharnaja Svekla, **10,** 42—45.

ERNOULD, L. (1946): L'autopolyploidie experimentale chez la betterave. I.B.A.B., **14,** 205—269.

FELTZ, H. (1953): Untersuchungen an diploiden und polyploiden Zuckerrüben. Cytologischen Untersuchungen der Mikrosporogenese und Betrachtungen über ihre Bedeutung für Zuckerrübenzüchtung. Ztsch. Pflztg., **32,** 275—300.

FITZGERALD, P. (1975): Value of sugar beet triploids as affected by reciprocal crosses. Report at the meeting of the study group "Genetics and Breeding". I.I.R.B. Carlow, Ireland, 1975.

FÜRSTE, W. (1958): Massnahmen zur Erhöhung des Anteils triploider Pflanzen in polyploiden Zuckerrüben. Beitr. zur Rübenforsch., **1,** 28—36.

GAEVSKAYA, I. G. (1972): The efficiency of selection of seed plants in tetraploid sugar beet. Osnovn. vivodi nauch. issled. rabot VNII, 35—36.

HOSOKAWA, S.—SAWAI, I.—SHICHIJI, M. (1952): A physiological comparison of the first stage of growth of diploid and tetraploid sugar beet grown in water culture. Ikushugaku Zasshi., **2,** 75—80.

JASSEM, M. (1961): Biology of pollination and fertilization in diploid × tetraploid sugar beet crosses. Part 1. Experiments on the germination of pollen produced by diploids and tetraploids. Genetica Polonica, **2/2,** 1—19.

KNAPP, E. (1967): Die genetische Grundlagen der Einzelfrüchtigkeit (Monokarpie) bei *Beta vulgaris*. Tag. Berichte dt. Akad. Landw.-Wiss. Berlin, **89,** 189—213.

KOLOMIEC, R. I.—Коломиец Р. И. (1966): Влияние наличия двусемянных клубочков у семенников ;на всхожесть и продуктивность односемянной сахарной свеклы. Основные выводы научно-исследовательских работ за 1961—1964 гг. Киев, ВНИИС, 51—54.

KOTUKOV, G. N. (1958): The use of some second year characters of sugar beet for breeding. Trud. Bot. Genet. Selekc., **31/3,** 230—244.

KOZLOVSKY, A. I.—ZABRODSKAYA, YA. V. (1972): A study of the genetic character singlefruitness in the main biotypes of monogerm sugar beet. Puti povisk. urozainost. polevikh kultur, **3,** 95—102.

LAHOUSSE, R. (1976): Use of monogerm tetraploid male-steriles and realization of triploid varieties of sugar beet. Report of the meeting of the Study Group "Genetics and Breeding". I.I.R.B., Bologna, Italy.

LOBODIN, O. K. (1972): Inheritance of monogermity in F_1 and F_2 hybrids between monogerm and intermediate forms. Osnovn. vivodi nauch. issled. rabot VNII 53—56.

LOBODIN, O. K. (1973): Study of the progeny of monogerm plants in relation to their content of multigerm seed balls. Sb. nauch. tr. Belotserk. opit. selekts., **5,** 84—89.

MAGASSY, L. (1960): A répa heterózisnemesítésének eredményei és további lehetőségei (Results and possibilities in heterosis of beet). MTA Agrártud. Oszt. Közl., **18,** 453—459.

MAGASSY, L. (1961): Adatok a poliploid Beta répák megtermékenyüléséhez és pollenvizsgálatához (On the fertility and pollen viability of polyploid Beta beets). Növénytermelés, **10,** 133—144.

MAGASSY, L. (1962a): Adatok a diploid és tetraploid cukorrépák pollenélettanához (Data on the pollen physiology of diploid and tetraploid sugar beets). Növénytermelés, **11**, 165—174.

MAGASSY, L. (1962b): A diploid és tetraploid cukorrépák levélzetének néhány alaktani jellegzetessége (Some morphological characteristics of diploid and tetraploid sugar beet leaves). Növénynem. és Növényterm. Kut. Int. Közl. Sopronhorpács, **2**, 33—38.

MAGASSY, L. (1975): Egymagvú cukorrépa hibridek vetőmagtermesztése (Seed propagation of the monogerm sugar-beet hybrids). Vetőmaggazdálkodás, **2**, 16—25.

MANZELEJ, I. I. (1958): The ways for further improvement of the productiveneness of monogerm sugar beet. Sacharnaja Svekla, **11**, 32—38.

MASUTANI, T.—NAKAJIMA, J. (1970): Studies on polyploid breeding in sugar beet. Bull. of Sugar Beet Res., **9**, 1—75.

NEGOVSKY, N. A.—TKACHENKO, A. A. (1959): Improving the productiveness of monogerm sugar beet. Sacharnaja Svekla, **5**, 38—41.

RASMUSSON, J.—LEVAN, A. (1939): Tetraploid sugar beets from colchicine treatments. (A preliminary note.) Hereditas, **25**, 97—102.

RÖSTEL, H. J. (1966): Züchtung und Vermehrung monokarper polyploider Zuckerrüben. Tag. Berichte dt. Akad. Landw.-Wiss. Berlin, **75**, 115—122.

RÖSTEL, H. J. (1972a): Besonderheiten an Samenträgern und Saatgut monokarper Zuckerrüben in Kleinwanzleben. Répaterm. Kut. Int. Közl. Sopronhorpács, **7**, 149—167.

RÖSTEL, H. J. (1972b): Ergebnisse der Züchtung auf Saatgutqualität und die Beziehungen zwischen Saatgutqualität und Leistung im ersten Vegetationsjahr. Répaterm. Kut. Int. Közl. Sopronhorpács, **7**, 7—21.

RÖSTEL, H. J. (1972c): Probleme und Ergebnisse der Züchtung monokarper tetraploider Zuckerrüben. Arch. Züchtungsforsch., **2/4**, 299—310.

RÖSTEL, H. J. (1975): Probleme und Möglichkeiten zur Verbesserung der Keimfähigkeit monokarper 3x Zuckerrübenhybriden durch Massnahmen der Züchtung, Saatguterzeugung und -aufbereitung. Arch. Züchtungsforsch., **5/3**, 100—121.

SAVITSKY, V. F. (1950): Monogerm sugar beets in the United States and their origin in the population. Proc. Amer. Soc. Sugar Beet Technol., **6**, 156—159.

SAVITSKY, V. F. (1952): A genetic study of monogerm and multigerm characters in beets. Proc. Amer. Soc. Sugar Beet Technol., **7**, 331—338.

SAVITSKY, V. F.—SAVITSKY, H. (1965): Weight of fruits in self fertile, male sterile, and selfsterile diploid and tetraploid monogerm Beta vulgaris L. Proc. Amer. Soc. Sugar Beet Technol., **13/7**, 621—644.

SCHNEIDER, H. (1960): Untersuchungen über die Beziehungen zwischen Knäuelgrosse, Reifegrad, Keimfähigkeit und Ploidiestufe bei Zuckerrübensaatgut. Wiss. Abhandl. dt. Akad. Landw.-Wiss. Berlin, Nr. 48. Beitr. Rübenforsch., **5**, 36—46.

SEDLMAYR, K. (1955): Poliploid cukorrépa hibridek (Polyploid sugar beet hybrids). Agrártudomány, **7**, 508—513.

SEDLMAYR, T. E. (1961): Untersuchungen über den Einfluss verschiedener Faktoren auf die Polidiestufenanteile einer anisoploiden Zuckerrübensorte. Züchter, **31**, 310—317.

SEDLMAYR, T. E. (1962): Inheritance of speed of germination in sugar beets (Beta vulgaris L.). Diss. Mich. State Univ., East Lansing (USA).

SHIVYREVA, E. T. (1973): The effect of the differentiation of populations of tetraploid monogerm sugar beet on seed quality. Puti povish. i sachar svekli, 47—53.

SPECKMANN, G. J.—KLOEN, D. (1956): The creation of tetraploid beets. Morphological and physiological characteristics of C_2 beets. Euphytica, **5**, 308—322.

SZOTA, Z. (1971): Report at the meeting of the Study Group "Genetics and Breeding". I.I.R.B., Einbeck, Germany.

USTIMENKO, S. P. (1963): Utilizing heterogeneity of seed in breeding and seed production of monogerm beets. Sacharnaja Svekla, **3**, 27—29.

ZABRODSKAYA, YA. V.—GRIB, S. I. (1976): Biological peculiarities of growth and development of mono- and multigerm sugar beet in Belorussia. Mez. Temat. Sb., **6**, 83—86.

ZAGREKAVA, V. M.—SEMYARYKHINA, S. YA. (1969): A study of the floral biology of polyploid sugar beet. Vesc. Akad. Nauk. BSSR Ser. Biol. Nauk. **3**, 67—70.

Acta Agronomica Academiae Scientiarum Hungaricae, Tomus 29 (3—4), pp. 265—282 (1980)

A STUDY OF SOME PHENOPHASES IN PLUMS

By

D. SURÁNYI

FRUIT RESEARCH STATION, CEGLÉD

The vegetative and generative phenophases of 91 plum varieties were observed between 1964 and 1970. Leaf-bud opening, the end of shoot growth, the colouring and falling of the leaves, the beginning of flowering, the date of flower-bud formation, the colouring of the fruit and the beginning of fruit ripening are characteristic of the variety. The phenophases do not begin at the same time every year; the extent of fluctuation indicates the climatic sensitivity of the phenophase. In the case of early leaf-bud opening and flowering the vegetation is generally protracted, while with late vegetation the dynamics of the phenophases is very fast. In plum varieties leaf-bud opening usually precedes flowering; the only exceptions are Bódi Plum, Gelbe Aprikosenpflaume and Red Nectarine. The beginning of leaf-bud opening and shoot growth and their intensity have a great influence on the date of flower-bud formation. From leaf-bud opening to the end of shoot growth some 90 days pass. Autumn colouring sets in about 80—100 days after the growth of the shoots has stopped, then 8—10 days later the leaves begin to fall. In some varieties the vegetation starts early and ends late (e.g. hungarica plums), while in other varieties early vegetation involves an early falling of leaves. There are also considerable differences between the fertilization groups. Leaf-bud opening takes place earliest and shoot growth ends very early in the practically self-sterile and self-sterile varieties. These two groups include mainly greengages, egg-plums, date-plums, and some spillings, domestica plums and mirabella varieties. The colouring and ripening of the fruit also start earlier in these groups than in the self-fertile and partly self-fertile plum varieties. The differentiation of the flower-buds is latest of all in the self-sterile varieties. The phenophases are in very close correlation with one another. Flower-bud formation depends primarily on the date of leaf-bud opening and shoot growth termination. No correlation between the date of fruit ripening and the differentiation of flower-buds could be demonstrated. The periodicity of plum varieties depends greatly on the date of flowering, so in Hungary preference should be given in plum production to varieties which blossom late.

Introduction

The onset of major phenophases in plum varieties has only been analysed in a relatively small number of papers. The only exception is flowering. The particular interest shown by researchers in the flowering phenophase is easy to understand, as some 2 months pass from the flowering time of early blossoming plum varieties (*P. cerasifera, P. salicina*) till that of late blossoming varieties; the danger of frost and the likelihood of pollination depend largely on the flowering time of the variety (in absolute and relative terms).

The geographical situation (latitude, altitude) and climatic factors may increase the differences between the varieties. For example, the flowering date of fruit species is 5 days earlier with every degree of latitude towards the equator, and 6 days earlier in the case of the plum variety Wildgoose (GARDNER *et al.* 1952).

HORN (1936) gives the flowering time for a number of plum varieties, but it is not clear whether his results are based on his own observations or on data taken from other authors. KEÖPECZY-NAGY (1943) gave the date of flowering in plums for nearly 70 years; these data agree in essence with more recent observations (TÓTH 1957). KOBEL (1954) also gives an analysis of flowering for a number of varieties, though most of them are of less importance in Hungary. BRÓZIK (1960) described the major phenophases, including the flowering period, of the most important hungarica plum varieties.

It is interesting to note that leaf-bud opening, the autumn colouring and falling of the leaves and the beginning of fruit colouring and ripening are dealt with in far fewer papers (TÓTH 1957, BRÓZIK 1960, VONDRÁČEK 1975). Italian researchers have recently published a detailed study on the pomological evaluation of plum varieties, but even this only discusses the dates of flowering and fruit ripening (NICOTRA *et al.* 1979).

Some of the authors approach the phenophase problems of plum varieties from a basically botanical point of view (HERRERO 1951, VONDRÁČEK 1975). Attention was called to the importance of correlational effects by TÓTH (1957), VONDRÁČEK (1975) and SURÁNYI (1980).

SURÁNYI (1980) evaluates observations made on 38 varieties between 1963 and 1970, since taxonomic work is also very useful in examining the varieties from an economic point of view. It has been found that leaf-bud opening, the beginning of flowering, the end of shoot growth, the beginning of autumn colouring and the falling of leaves, and the beginning of fruit colouring and ripening show close correlations, in spite of the variability of the meteorological factors.

The present paper describes the vegetative and generative phenophases for 91 varieties, which is not only useful in classifying the historical plum varieties, but also makes it possible to give a uniform evaluation of the large Cegléd plum variety collection. Extensive work is needed before the orchard is disposed of, because a number of valuable varieties, whose importance in breeding cannot be neglected, could be saved.

Material and Method

In 1954—56 nearly 200 plum varieties grafted to Myrobalan seedlings were planted at Cegléd; the present paper contains the average phenophase data of 5 trees. The orchard is situated on flat land with good quality chernozem soil at a height of 98 m above sea level, at a latitude of 47°50′ north and a longitude of 19°42′ east.

The following phenophases were observed from year to year: the beginning of leaf-bud opening, the end of shoot growth, the beginning of autumn colouring and the beginning of leaf abscission. In addition, continuous records were kept of the beginning of flowering, the end of flowering, the beginning of petal shedding (data on the latter two phenophases are not included in this paper), the beginning of fruit colouring and the beginning of fruit ripening. Between 1969 and 1971 the beginning of flower-bud differentiation was also studied.

Since a large number of varieties were involved, the microscope examinations had to be simplified to some extent. Five buds per spur were taken from the southern branch of each tree for each variety and fixed in 70% alcohol. The first samples were taken on 1st June, sampling was continued every 10—12 days until 10th September.

The buds were examined using Elsman's dissection method under a stereomicroscope with 100× enlargement. Phase IV of the stages of bud development described by ELEK (1966) was regarded as the beginning of flower-bud formation. At this stage the flower organs are already differentiated, so this phase is easy to determine in the case of a large number of samples. The beginning of flower-bud differentiation precedes this stage of development by about 2—3 weeks.

Between 1964 and 1970 a statistical evaluation of the onset of 8 phenophases was made, and between 1969 and 1971 an analysis of the beginning of flower-bud formation. The annual variety averages represented the individual replications. Each phenophase was expressed as the number of days from the first day of the year.

23 self-fertile, 15 partly self-fertile, 20 practically self-sterile and 33 self-sterile plum varieties were included in the study, according to the classification given by TÓTH (1967). The variance analysis of the 8 phenophases was carried out for each group separately, then the basic data for the individual groups was obtained from the varietal averages.

The year dependence of the vegetative and generative phenophases was also studied; the years were compared in an analysis with 91 replications.

Finally, for the purpose of correlation calculations, the average values of the phenophases were compared in all possible combinations. Since the beginning of flower-bud differentiation was only observed for three years, the dependent variable was also included for only three years (1969—1971) in the correlation calculation. When the average was calculated the 1971 data series of the 8 phenophases was also included, but this data series is not presented in Tables 1—4. The BBI-values of the varieties were only included in the study for the purpose of correlation calculations; the way in which they were determined was described in an earlier paper (SURÁNYI 1980). The percentage BBI-value is obtained from the difference in yield per tree between two successive years divided by the joint yield for the same years.

Results

1. *Vegetative phenophases*

a) *Leaf-bud opening.* Only in three of the plum varieties examined does leaf-bud opening take place after flower opening (Bódi Plum, Gelbe Aprikosenpflaume and Red Nectarine); in all the other plum varieties flower opening is always preceded by leaf-bud opening. The fluctuation over an average of seven years is 14.5 days.

Leaf-bud opening is early (85—90 days, $\bar{x} = 87.8$) in 28 varieties, medium early (91—95 days, $\bar{x} = 92.8$) in 55 and late (96—106 days, $\bar{x} = 99.6$) in 8 varieties. The bursting of the vegetative buds of the plum varieties occurs between the 85th and the 100th day, that is, between 26th March and 10th April. The extreme values are 75 and 110 days.

The period from leaf-bud opening (in 3 varieties) or flowering (in 88 varieties) to the end of leaf abscission in the vegetation period is 228 days, in medium varieties 225 days, and in late varieties 222 days.

It is also worth examining the beginning of the vegetation period of the trees as a function of the year. According to our observations leaf-bud opening takes place between the 85th and the 99th day, and the fluctuation is much greater than can be demonstrated on the basis of flowering (Tables 1 and 2).

b) *End of shoot growth.* The shoot growth of plum varieties takes some 90 days. The data presented here refer to the first growth period, but as there is generally no further growth in plums, the end of the first growth period

Table 1

Vegetative phenophases of plum varieties

Varieties	Leaf-bud opening	End of shoot growth	Beginning of leaf colouring	Beginning of leaf abscission
Self-fertile				
Agen 1	90	181	274	284
Angoulème	90	186	272	278
Anna Späth	97	188	263	276
Besztercei Muskotály	94	189	276	282
Besztercei Szilva	95	185	283	289
Blau Herrenpflaume	92	184	267	281
Bódi Szilva	102	180	269	281
Borsumer	92	186	271	281
Bunter Perdrigon	93	180	267	277
Bühler Frühzwetsche	92	190	262	282
Gelbe Mirabelle	92	179	273	280
Gustave Egger	85	187	273	281
Italian Prune	90	187	272	283
Kaiser von Milan	95	183	271	282
Korai Zöld	87	178	268	277
Königin von Bosnia	90	186	271	283
Letricourt	93	184	273	282
Liegel	90	190	275	280
Ontario	93	182	263	280
Prince of Wales	86	185	272	282
Septembrische Mirabelle	93	185	272	279
Vörös Szilva	94	186	268	278
Wangenheim	94	183	270	181
F-value	1.89*	28.65***	2.84***	2.18**
LSD 5%	5.07	2.77	6.69	5.31
Partly self-fertile				
Ageni 2	92	186	274	282
Belle de Louvain	93	178	272	282
Beregi Datolya	92	187	273	284
Berta Waschmann	92	190	271	283
Early Favourite	95	188	267	276
Emma Leppermann	91	179	270	277
Englebert	81	189	266	281
Gömöri Nyakas	95	178	269	283
Grand Sugar	91	184	269	280
Haffner	100	186	270	280
Nancymirabelle	93	189	272	283
Procuceur	94	187	266	279
Red Eggplum	86	182	262	284
Violette Königin	85	184	273	283
Violette Reneklode	87	182	271	282
F-value	3.65***	3.64***	4.96***	2.71**
LSD 5%	4.84	6.11	5.13	4.18
Practically self-sterile				
Althann	92	181	271	287
Biondeck	87	178	268	277
Bleu de Belgique	93	187	270	281
Csúcsos Szilva	97	180	273	281
Dark-blue Eggplum	91	185	274	284
Frühe Königspflaume	92	185	269	279

(Table 1 continued)

Varieties	Leaf-bud opening	End of shoot growth	Beginning of leaf colouring	Beginning of leaf abscission
Grand Duke	86	185	273	280
Green Gage	94	186	266	284
Imperial	87	187	272	282
Jefferson	92	176	270	282
Primate	88	163	269	279
Prugna d'Italia	92	186	275	283
Ruth Gerstetter	89	185	269	282
Sainte Catherine	92	181	272	280
Sasbacher Frühzwetsche	89	185	262	278
Szigeti Zöld	94	188	272	290
Violette Diapre	94	181	268	279
Violette Perdrigon	94	187	269	281
Weisse Königin	94	168	273	284
Wilma Späth	88	181	269	278
F-value	109.88***	6.13***	3.60**	26.76***
LSD 5%	6.18	7.25	4.53	4.95
Self-sterile				
Angeline Burdett	88	185	270	278
Brassai	93	184	271	282
Catalan	98	189	274	282
Cochet	89	180	274	284
Columbia	93	187	271	281
Daniel	89	189	268	282
Diamant	93	175	271	284
Gelbe Aprikosenpflaume	103	183	272	282
Gelbe Hartwiss	91	182	275	289
Gelbe Herrenpflaume	91	177	269	280
Golden Sugar	92	179	273	280
Gondini	92	186	266	281
Jodoigne	93	189	270	277
Kirke's Plum	94	179	270	279
Königin der Mirabelle	89	182	269	278
Königsbacher Frühzwetsche	86	184	269	278
Late Muscate	92	187	268	276
Markuja	89	187	266	279
McLaughlin	89	188	268	278
Meroldts Reneklode	85	167	274	282
Metzer Mirabelle	88	178	269	280
Montfort	92	179	262	281
Pacific	94	185	273	280
Pond's Seedling	93	184	278	285
Prince Red	94	177	267	280
Red Nectarine	106	188	272	282
Reine-Claude de Nancy	93	189	269	281
Späths Früheste	94	179	272	280
St. Étienne	94	178	272	279
Tragedia	92	178	271	281
Violette Jerusalemspflaume	96	181	266	276
Washington	92	182	272	280
Yellow Eggplum	86	180	268	281
F-value	10.98***	2.47*	3.57**	1.53
LSD 5%	6.17	8.91	4.59	5.96

* $p = 5\%$ ** $p = 1\%$ *** $p = 0.1\%$

Table 2

Vegetative phenophases in plums

Year	Leaf-bud opening	End of shoot growth	Beginning of leaf colouring	Beginning of leaf abscission
1964	99.0	194.2	269.9	280.8
1965	86.3	183.3	268.2	279.1
1966	85.3	183.8	268.9	278.7
1967	90.7	179.8	270.3	279.0
1968	89.9	180.7	268.9	275.3
1969	93.2	179.1	268.7	277.2
1970	90.4	181.1	269.6	278.1
F-value	3.65**	3.64**	3.96**	2.71*
LSD 5%	4.80	6.11	5.13	4.18

is also the end of shoot growth. The greatest difference between the varieties, which can be expressed in days, is shown in this phenophase. Shoot growth is completed very early (in 163—175 days, $\bar{x} = 171.9$) in 14 varieties, at a medium period (176—183 days, $\bar{x} = 180.8$) in 26 varieties, and late (after 184—190 days, $\bar{x} = 186.6$) in 51 varieties. The extreme values (143 and 208 days) give a calendar period between 23rd May and 27th July.

The shoot growth of plum varieties was completed the latest (194.2) in 1964, and the earliest (179.1) in 1969. If the date of the end of shoot growth is compared with leaf-bud opening it is found that after the first vegetative phenophase the plum trees have still not eliminated the effects of meteorological factors. Shoot growth is completed earlier or later depending on the date of leaf-bud opening (Tables 1 and 2).

c) *Beginning of leaf colouring*. The beginning of autumn colouring is of great importance for the preparation for overwintering. On average the gradual discoloration of the foliage leaves begins some 80—90 days after the completion of shoot growth; the flower-bud primordia are formed in the same period. The discoloration of the leaves begins early (after 262—270 days, $\bar{x} = 267.5$) in 45 plum varieties, at an average time (271—276 days, $\bar{x} = 272.6$) in 44, and late (277—283 days, $\bar{x} = 280.5$) in 2 varieties.

The time interval calculated from these varieties is 3 weeks, but the absolute period increases to 45 days. On average, if the discoloration of the leaves begins on the 262nd to 283rd day, this means from 19th September to 10th October. A comparison of year averages only reveals very small differences; the onset of leaf colouring depends least of all on climatic factors. Even the beginning of leaf abscission is more closely related with changes in the weather than the colouring of the leaves (Tables 1 and 2).

d) *Beginning of leaf abscission*. The last phenophase in the vegetation period is also specific to the variety. Although on the basis of these varieties the beginning of leaf abscission has a narrow range, from 3rd to 16th October, i.e. from the 276th to the 289th day, the absolute fluctuation is much greater: from 19th September to 6th November; that is, it occurs between the 262nd and the 310th day.

With respect to the beginning of leaf abscission three groups can be formed. The leaves begin to fall early (276th—280th day, $\bar{x} = 278.6$) in 39 varieties, at an average time (281st—285th day, $\bar{x} = 282.2$) in 48 varieties, and late (286th—290th day, $\bar{x} = 288.7$) in 4 plum varieties.

A minor yearly fluctuation as to when leaf abscission began was observed: the trees started shedding their leaves earliest (275.3) in 1968 and latest (280.8) in 1964 (Tables 1 and 2).

In some varieties the vegetative phenophases begin either much earlier or much later than the average. These characteristic extreme values are represented by the following varieties:

Leaf-bud opening

earliest: Gustave Egger (85), Violette Königin (85) Meroldts Reneklode (85)

latest: Red Nectarine (106), Gelbe Aprikosenpflaume (103), Bódi Plum (102), Haffner (100).

End of shoot growth

earliest: Primate (163), Meroldts Reneklode (167), Weisse Königin (168)

latest: Bühler Frühzwetsche (190), Liegel (190), Berta Waschmann (190).

Beginning of leaf colouring

earliest: Bühler Frühzwetsche (262), Red Eggplum (262), Sasbacher Frühzwetsche (262), Montfort (262)

latest: Besztercei Plum (283), Pond's Seedling (278), Gelbe Hartwiss (275).

Beginning of leaf abscission

earliest: Anna Späth (276), Early Favourite (276), Late Muscate (276), Violette Jerusalemspflaume (276)

latest: Szigeti zöld (290), Besztercei Plum (289), Gelbe Hartwiss (289).

2. *Generative phenophases*

a) *Beginning of flowering*. As was mentioned above 3 plum varieties, Bódi Plum, Gelbe Aprikosenpflaume and Red Nectarine, blossom before their leaf-buds begin to open. In the other varieties flowering begins on average 14.5 days after leaf-bud opening.

At Cegléd the plum varieties began to flower on the 101st—110th day of the year, that is between 11th and 20th April over an average of 7 years. Flowering took place early (101st—103rd day, $\bar{x} = 102.3$) in 23 varieties, at an average time (104th—106th day, $\bar{x} = 104.7$) in 49 varieties, and late (107th—110th day, $\bar{x} = 107.6$) in 19 varieties. There are also extreme cases, so as much as 25 days may in fact pass from the beginning of flowering in the earliest blossoming variety to that in the latest one (95th—120th day).

The time from the beginning of flowering to the beginning of petal shedding is the flowering period. The flowering period was found to be 13 days in early blossoming varieties, 12.8 days in those flowering at a medium time, and 11.5 days in late blossoming varieties.

The period of fruit development showed an interesting trend relative to the beginning of flowering. The time between flowering and fruit ripening was the shortest (99.1 days) in the case of varieties which blossom at a medium time, somewhat longer with those flowering early (105.2 days), and the longest for late blossoming varieties (110.6 days). No positive correlation was actually obtained between the beginning of flowering and the date of fruit development.

Between 1964 and 1970 the flowering period ranged from 100 to 109 days, that is, the effects of climatic factors were largely concealed by variety effects, but when the role of the meteorological factors is considered for each variety separately it can be clearly demonstrated (Tables 3 and 4).

b) *Beginning of flower differentiation.* The data of flower organ differentiation in the buds of 91 varieties was studied between 1969 and 1971. This phase was found to be particularly suitable for carrying out stereomicroscope examinations on a large number of buds.

The flower organs become differentiated between the 182nd and 246th day, that is between 1st July and 3rd September; the absolute interval is still greater: 171—256 days. The differentiation of the flower-buds starts early (182nd—200th day, $\bar{x} = 189.2$) in 16 varieties, at a medium time (201st—220th day, $\bar{x} = 213.2$) in 35 varieties, and late (221st—246th day, $\bar{x} = 232.0$) in 40 varieties.

About 100 days pass from flowering to the beginning of flower-bud formation, though in some varieties this period may be as long as 130 days or even more (Kaiser von Milan, Letricourt, Early Favourite, Gömöri nyakas, Haffner, Procuceur, Csúcsos szilva, Green Gage, Violette Perdrigon, Catalan, Cochet, Pacific, Pond's Seedling, Prince Red and Violette Jerusalempflaume). On the other hand, in some varieties in the collection less than 100 days pass between flowering and the beginning of flower-bud formation (Bódi szilva, Gustave Egger, Prince of Wales, Red Eggplum, Violette Königin, Violette Reneklode, Biondeck, Grand Duke, Imperial, Ruth Gerstetter, Wilma Späth, Gelbe Aprikosenpflaume, Königsbacher Frühzwetsche, Meroldts Reneklode, Metzer Mirabelle and Yellow Eggplum).

Table 3

Generative phenophases of plum varieties

Varieties	Beginning of			
	flowering	flower differentiation	fruit colouring	fruit ripening
Self-fertile				
Agen 1	103	202	225	236
Angoulème	105	209	206	213
Anna Späth	104	215	220	236
Besztercei Muskotály	108	223	214	228
Besztercei Szilva	107	220	215	228
Blau Herrenpflaume	106	220	208	223
Bódi Szilva	101	186	198	214
Borsumer	107	233	216	229
Bunter Perdrigon	106	207	208	215
Bühler Frühzwetsche	106	208	209	227
Gelbe Mirabelle	110	225	202	210
Gustave Egger	105	193	220	229
Italian Prune	106	211	217	229
Kaiser von Milan	107	246	227	238
Korai Zöld	104	207	191	200
Königin von Bosnia	107	230	221	236
Letricourt	108	241	227	237
Liegel	102	205	197	201
Ontario	105	233	209	219
Prince of Wales	104	189	209	219
Septembrische Mirabelle	106	220	228	239
Vörös Szilva	102	225	212	224
Wangenheim	109	243	214	226
F-value	2.23**	7.11***	98.55***	24.60***
LSD 5%	4.00	5.03	9.25	7.07
Partly self-fertile				
Agen 2	105	205	225	236
Belle de Louvain	106	229	206	216
Beregi Datolya	105	210	226	242
Berta Waschmann	103	220	215	227
Early Favourite	104	238	189	202
Emma Leppermann	105	217	192	200
Englebert	103	203	211	224
Gömöri Nyakas	108	238	213	228
Grand Sugar	105	214	209	222
Haffner	106	245	213	223
Nancymirabelle	107	230	240	246
Procuceur	104	239	214	224
Red Eggplum	103	182	200	209
Violette Königin	105	191	218	231
Violette Reneklode	106	187	215	227
F-value	0.67	12.23***	15.69***	2.16*
LSD 5%	4.82	5.17	9.13	10.47
Practically self-sterile				
Althann	105	214	214	224
Biondeck	104	194	188	201
Bleu de Belgique	103	221	217	225
Csúcsos Szilva	107	240	230	237
Dark-blue Eggplum	106	219	214	226
Frühe Königspflaume	105	224	192	199

(Table 3 continued)

Varieties	Beginning of			
	flowering	flower differentiation	fruit colouring	fruit ripening
Grand Duke	102	189	218	232
Green Gage	105	237	201	224
Imperial	102	191	197	208
Jefferson	104	227	217	230
Primate	107	210	227	239
Prugna d'Italia	103	218	211	223
Ruth Gerstetter	102	184	184	193
Sainte Catherine	105	219	216	230
Sasbacher Frühzwetsche	102	215	185	195
Szigeti Zöld	105	227	210	222
Violette Diapre	107	230	195	204
Violette Perdrigon	105	239	214	224
Weisse Königin	106	225	227	233
Wilma Späth	101	196	193	208
F-value	1.62*	19.28***	16.24***	33.78***
LSD 5%	4.06	5.36	10.08	7.56
Self-sterile				
Angelina Burdett	102	216	208	220
Brassai	107	224	225	239
Catalan	108	240	210	220
Cochet	104	236	218	222
Columbia	104	229	204	221
Daniel	102	216	195	211
Diamant	105	222	223	228
Gelbe Aprikosenpflaume	101	190	221	231
Gelbe Hartwiss	105	212	212	223
Gelbe Herrenpflaume	107	217	204	211
Golden Sugar	110	220	219	230
Gondini	106	219	226	236
Jodoigne	105	232	224	237
Kirke's Plum	106	226	207	217
Königin der Mirabelle	103	204	204	215
Königsbacher Frühzwetsche	102	188	198	206
Late Muscate	104	225	220	236
Markuja	103	207	205	213
McLaughlin	103	208	210	220
Meroldts Reneklode	101	184	212	223
Metzer Mirabelle	103	196	223	227
Montfort	104	229	201	210
Pacific	105	236	206	216
Pond's Seedling	105	234	221	233
Prince Red	104	240	207	217
Red Nectarine	105	214	195	201
Reine-Claude de Nancy	104	227	204	214
Späths Früheste	105	230	188	198
St. Étienne	107	225	208	222
Tragedia	105	217	196	204
Violette Jerusalemspflaume	106	239	191	201
Washington	108	221	205	213
Yellow Eggplum	103	187	221	233
F-value	1.85+	19.20***	10.47***	23.98***
LSD 5%	4.04	5.88	9.15	9.00

+ p = 10% ** p = 1% *** p = 0.1%

Table 4

Generative phenophases of plums

Year	Beginning of			
	flowering	flower differentiation	fruit colouring	fruit ripening
1964	107.4	—	211.5	222.7
1965	109.4	—	223.8	233.5
1966	105.6	—	206.0	216.9
1967	103.4	—	211.9	222.7
1968	100.1	—	205.3	216.7
1969	106.4	225.1	205.9	217.0
1970	104.3	211.1	208.6	221.5
1971	—	213.7	—	—
F-value	1.97+	5.12**	15.69***	10.55***
LSD 5%	4.82	7.88	6.13	8.47

+ p = 10%
** p = 1%
*** p = 0.1%

The process of flower-bud formation starts after the shoot has stopped growing; exceptions are the varieties Ruth Gerstetter and Red Eggplum. If only the 1969—1971 phenophase data are taken into consideration the varieties Prince of Wales, Grand Duke, Imperial and Königsbacher Frühzwetsche can also be placed in this group. In fact, the end of shoot growth and the beginning of flower-bud formation take place on the same day, or within one or two days of each other.

Compared to 1969 the flower-buds began to develop earlier in the two subsequent years; the difference proved significant (Tables 3 and 4).

c) *Beginning of fruit colouring.* The fruit of the plum varieties starts to colour on the 184th to 240th day. In the blue, red, yellow and greenish-yellow varieties the green colour of the fruit is slowly replaced by the colour characteristic of the variety. The colouring of plum fruits generally takes place between 3rd July and 28th August; the absolute interval is somewhat longer, 73 days (from the 179th to the 252nd day).

Fruit colouring takes place early (184th—200th day, $\bar{x} = 192.4$) in 18 varieties, at a medium time (201st—220th day, $\bar{x} = 210.9$) in 54, and late (221st—240th day, $\bar{x} = 225.6$) in 19 varieties. The difference between the earliest and the latest date over 7 years was 18.5 days; the fluctuation is considerable, which gives definite proof of the role of climatic factors (Tables 3 and 4).

d) *Beginning of fruit ripening.* After 8—10 days of colouring the fruit begins to ripen and is ready for consumption in a shorter or longer time depending on the variety. The fruits of all plum varieties generally become ripe between 12th July and 3rd September; the extreme values over 7 years were the 189th and 260th days. The fruits ripen early (193rd—210th day, $\bar{x} = 202.2$) in 18 varieties, at a medium time (211th—225th day, $\bar{x} = 220.1$) in 35, and late (226th—246th day, $\bar{x} = 231.0$) in 38 varieties.

Judging by the years examined, the date of ripening may deviate from the average by as much as 16 days, that is, the ripening date depends greatly on the climatic factors (Tables 3 and 4).

The generative phenophases are also specific to the variety; the extreme values are indicated below.

Beginning of flowering

earliest: Bódi szilva (101), Wilma Späth (101), Gelbe Aprikosenpflaume (101), Meroldts Reneklode (101)
latest: Gelbe Mirabelle (110), Golden Sugar (110), Wangenheim (109).

Beginning of flower differentiation

earliest: Red Eggplum (182), Ruth Gerstetter (184), Meroldts Reneklode (184)
latest: Kaiser von Milan (246), Haffner (245), Wangenheim (243), Letricourt (241).

Beginning of fruit colouring

earliest: Ruth Gerstetter (184), Sasbacher Frühzwetsche (185), Biondeck (188), Späths Früheste (188)
latest: Nancymirabelle (240), Csúcsos szilva (230), Septembrische Mirabelle (228).

Beginning of fruit ripening

earliest: Ruth Gerstetter (193), Sasbacher Frühzwetsche (195), Späths Früheste (198), Frühe Königspflaume (199)
latest: Nancymirabelle (246), Beregi Datolya (242), Primate (239), Brassai (239).

3. Phenological characterization of self-fertilization groups in plum

In Tables 1 and 3 the plum varieties are placed in 4 categories; the average data for all the varieties were used as replications in calculating the data in Table 5.

The vegetative buds were found to open earliest in the self-sterile varieties; the difference compared to the other three groups was significant. The difference was less apparent as regards the beginning of flowering; the only demonstrable difference was found between the self-fertile and the practically

Table 5

Phenometric characterization of different plums and their BBI-values

Measurement	Self-fertile	Partly self-fertile	Practically self-sterile	Self-sterile	LSD 5%	Significance
	a	b	c	d		
Leaf-bud opening	91.1	92.1	91.5	88.0	2.10	a—d, b—d, c—d
Beginning of flowering	105.6	104.6	104.4	105.1	1.26	a—c
End of shoot growth	184.2	184.1	182.1	181.2	1.93	a—c, a—d, b—c, b—d
Beginning of fruit colouring	212.5	212.6	207.1	209.5	3.49	a—c, a—d, b—c, b—d
Beginning of flower differentiation	217.0	216.6	215.7	218.5	2.14	c—d
Beginning of fruit ripening	224.2	223.7	218.5	219.4	2.71	a—c, a—d, b—d
Beginning of leaf colouring	270.4	269.1	270.3	270.2	1.37	a—b, b—c
Beginning of leaf abscission	280.8	280.9	277.4	280.7	1.87	a—c, b—c, b—d
BBI-value	34.8	33.5	47.8	38.3	3.88	a—c, a—d, b—c, b—d, c—d

self-sterile varieties. Flowering occurs 17.1 days after leaf-bud opening in self-sterile plums, 14.5 days after leaf-bud opening in self-fertile varieties, while in the partly self-fertile and practically self-sterile varieties this interval is 12—13 days.

In the practically self-sterile and self-sterile varieties the shoot growth is completed 2—3 day searlier on average than in the self-fertile and partly self-fertile groups. The varieties can again be divided into two groups on the basis of the beginning of fruit colouring and fruit ripening. The flower-buds develop latest in the self-sterile varieties, although the leaf-buds open the earliest of all in this group. The correlation is positive though the average values of the self-fertile group do not support this.

The colouring of the leaves begins earliest in the partly self-fertile varieties, while leaf abscission is the earliest in the practically self-sterile plums; no significant difference was found between the other groups.

For the correlation calculations it was deemed necessary to determine the BBI-index. On the basis of the 91 varieties examined it can be seen that the plum species and varieties have a great inclination to alternate. A value below 20% can be regarded as very good; varieties with such values are: Late Muscate (10.2), Borsumer (13.8), Bühler Frühzwetsche (13.8), Späths Früheste (14.2), Daniel (16.8), Italian Prune (17.0), Pond's Seedling (17.0), Königin von

Bosnia (18.0), Agen 2 (18.0), Yellow Eggplum (18.0), Biondeck (18.2), Korai zöld (18.2), Early Favourite (19.6) and McLaughlin (19.8). Alternation is the lowest in the partly self-fertile varieties, and the highest in the practically self-sterile group (Table 5).

4. *Results of correlation studies*

Interrelations between the 8 phenophases were evaluated in 28 regression analyses. The beginning of leaf-bud opening and flowering (with the exception of Bódi szilva, Gelbe Aprikosenpflaume and Red Nectarine), the beginning of fruit colouring and ripening and the beginning of flower-bud differentiation are in very close correlation with the beginning of leaf-bud opening and flowering. Furthermore, it can be established that the beginning of flowering, the

Table 6

Summary of correlational measurements on plums

Relationship between	r-value
Leaf-bud opening and Beginning of flowering	+0.502***
Leaf-bud opening and End of shoot growth	+0.141
Leaf-bud opening and Beginning of fruit colouring	+0.405***
Leaf-bud opening and Beginning of flower differentiation	+0.812***
Leaf-bud opening and Beginning of fruit ripening	+0.862***
Leaf-bud opening and Beginning of leaf colouring	+0.036
Leaf-bud opening and Beginning of leaf abscission	+0.011
Beginning of flowering and End of shoot growth	−0.117
Beginning of flowering and Beginning of fruit colouring	+0.335**
Beginning of flowering and Beginning of flower differentiation	+0.109
Beginning of flowering and Beginning of fruit ripening	+0.312**
Beginning of flowering and Beginning of leaf colouring	+0.207*
Beginning of flowering and Beginning of leaf abscission	+0.061
End of shoot growth and Beginning of fruit colouring	−0.040
End of shoot growth and Beginning of flower differentiation	+0.317**
End of shoot growth and Beginning of fruit ripening	+0.060
End of shoot growth and Beginning of leaf colouring	+0.021
End of shoot growth and Beginning of leaf abscission	+0.018
Beginning of fruit colouring and Beginning of flower differentiation	+0.175+
Beginning of fruit colouring and Beginning of fruit ripening	+0.963***
Beginning of fruit colouring and Beginning of leaf colouring	+0.336
Beginning of fruit colouring and Beginning of leaf abscission	+0.129***
Beginning of flower differentiation and Beginning of fruit ripening	+0.224*
Beginning of flower differentiation and Beginning of leaf colouring	+0.416***
Beginning of flower differentiation and Beginning of leaf abscission	+0.091
Beginning of fruit ripening and Beginning of leaf colouring	+0.294**
Beginning of fruit ripening and Beginning of leaf abscission	+0.130
Beginning of leaf colouring and Beginning of leaf abscission	+0.163
Beginning of flowering and BBI-value	−0.231*
Beginning of fruit ripening and BBI-value	−0.102

+ p = 10%
* p = 5%
** p = 1%
*** p = 0.1%

colouring and ripening of the fruit and the colouring of the leaves are also in correlation with each other. The end of shoot growth has a remarkable effect on the flower-bud formation in the plum varieties, which is why there is a positive correlation between them. Only a few varieties (Red Eggplum, Ruth Gerstetter, Prince of Wales, Grand Duke, Imperial and Königsbacher Frühzwetsche) showed a negative trend, since the differentiation of the flower-buds started before the shoots stopped growing.

Fruit colouring is in close correlation with fruit ripening and with the beginning of leaf colouring. The fact that early colouration makes earlier flower formation possible is, however, much more important. This is even more apparent when considered as a function of the beginning of fruit colouring ($r = +0.224$ and $P = 5\%$). In varieties with early fruit ripening leaf colouring also begins earlier; in fact, the vegetation of the trees is faster. Considering the need to prepare for the winter and the possibility of early frosts this varietal feature can be regarded as favourable.

Finally, investigations were made to discover to what extent alternation, which is an unfavourable characteristic of plum trees, depends on the phenophases. In the present case examinations were only made on its relationship with two phenophases, since these were thought to be causal relations. A high BBI-value is much more frequent in plum varieties which flower and ripen early than in trees with late flowering and fruit ripening. The role of the ripening time could only be demonstrated to a lesser extent in the 91 plum varieties examined; the relationship is only a trend.

Discussion

Observations on 4 vegetative and 4 generative phenophases in plum varieties over a number of years provided a sufficient basis for drawing general conclusions. The results of our investigations agree with those obtained by Tóth (1957) under different site conditions, while there is only a slight difference between the flowering data of Keöpeczy-Nagy (1943) and Tóth (1957), which were obtained under very similar site conditions in the Buda area. At Cegléd flowering begins some 3—4 days earlier than at Kamaraerdő in Buda, thus showing the importance of the geographical situation. Latitude (irrelevant in this case), altitude, and the degree of exposure greatly modify the beginning, duration and dynamics of vegetation.

Earlier it was found that the leaf-buds of Bódi szilva (*Prunus insititia*) burst before flowering begins. The vegetation in *Prunus cerasifera* is incredibly fast (Alutscha) and the same can be said of *P. italica* convar. *pomariarum*. On the other hand, Bódi szilva and the eggplums (*P. italica* convar. *ovoidea*) have long vegetation periods. Shoot growth in high productivity greengages (*P. italica* convar. *claudiana*), domestic plums (*P. domestica*) and in some eggplum varieties (*P. italica* convar. *ovoidea*) takes much longer than in other groups of plums (SURÁNYI 1980).

Since TÓTH (1957) made his observations on almost the same varieties, in discussing the present results reference is always made to this work instead of making comparisons with the copious literature, which is difficult to survey. Data collected over ten years are included in Tóth's study and these are confirmed in many respects by the present observations. A good example of this is the question of flowering time. There are stable (less weather dependent) and unstable varieties. In the varieties Kaiser von Milan, Königin von Bosnia, Szigeti zöld, etc. the fluctuation of the absolute flowering time is 10.5 days, while in Tragedia, Cochet, Jodoigne, etc., which are unstable varieties, it is 14.2 days. The stable varieties blossom considerably later than the unstable ones. The flowering period is longer at Cegléd than at Kamaraerdő almost every year; that is, the classification is valid not only for growing sites but also for different years.

This is why the 3—4 days advantage at Cegléd at the beginning of flowering increases to 6—8 days by the time of full blossoming, and the petals begin to drop 11—12 days earlier at Cegléd than at Kamaraerdő. According to TÓTH (1957) plum trees start flowering on 18th April, KEÖPECZY-NAGY (1943) reports the beginning of flowering on 19th April, while in the present investigations flowering began on 14—15th April on average. With respect to the duration of flowering smaller differences were found between early, medium and late varieties than those reported by Tóth.

The flowering period is short in the varieties Blau Herrenpflaume, Beregi datolya and Szigeti zöld: 6.4—6.6 days at Kamaraerdő, and 10.2—12.5 days at Cegléd over the average of the three varieties. In the varieties Gelbe Aprikosenpflaume, Biondeck and Green Gage, which have the longest flowering periods, 11.0—11.2 (at Cegléd 14.5—15.3) days pass from the beginning of flowering to the beginning of petal shedding.

TÓTH refers to the work of Ro (1929) when discussing the positive correlation between flowering and flower-bud formation. The present observations on 91 varieties did not confirm this theory; the phenophase of leaf-bud opening was found to be much more important (Table 6). The varieties in the different flowering groups do in fact form their flower-buds earlier or later according to the hypothesis proposed by Tóth, but the trend is not significant.

Tufts — Morrow and Johansson (TÓTH 1957) found that the differentiation of the flower-buds was already highly intensive between 29th June and 2nd September. Year, variety, rootstock and cultural practices may greatly modify the beginning of flower-bud formation. A northerly position (Scandinavia, Scotland, Canada) causes a 3—6 week delay in flower formation.

Flower-bud differentiation takes place at Cegléd between 1st July and 3rd September; over the average of 91 varieties the 217th day (5th August) is the date when the flower organs differentiate. The actual beginning of flower-bud formation (phase I) is followed some 2—3 weeks later by phase IV (ELEK 1966), which was also indicated by the authors. Thus, the calendar date given here is almost identical with the Swedish and Moldavian data, and the effect of the geographical situation is not apparently felt (RO 1929, KOBEL 1954, MOSTOLOVITSKA 1972).

The end of shoot growth is generally followed by flower-bud formation, but in the varieties Ruth Gerstetter, Red Eggplum, Prince of Wales, Grand Duke, Imperial and Königsbacher Frühzwetsche the situation is reversed. The other extreme is represented by a group of varieties in which the shoot growth is completed more than 50 days before the flower organs in the flower-buds become differentiated. These varieties are Kaiser von Milan (63), Prince Red (63), Gömöri nyakas (60), Csúcsos szilva (60), Haffner (59), Violette Jerusalemspflaume (58), Cochet (56), Violette Perdrigon (52), Green Gage (51), Catalan (51), Pacific (51), Späths Früheste (51), Early Favourite (50) and Pond's Seedling (50).

There is a significant difference in the time of fruit ripening between these two extreme groups: the former varieties begin to ripen on 30th July and the latter on 15th August.

The fruits take 56 days to become coloured, though according to Tóth this figure is 51 days; the range of varieties colouring earliest and latest was found to be the same. A strong similarity was also found in the beginning of fruit ripening, though by contrast to Tóth's results, in the present investigations colouring was closely correlated to ripening. Varieties with yellow, green or yellowish-green fruits ripen very fast (Korai zöld, Weisse Königin, Gelbe Herrenpflaume, Angoulème, etc.); those with blue and red fruits have a long ripening period (Königin von Bosnia, Besztercei szilva, Borsumer, Italian Prune, Kaiser von Milan, etc.).

The importance of the vegetative phenophases is suggested indirectly by the studies of RIEHS (1933). TÓTH (1957) also observed that the suction force during withering was 8 at. in varieties blossoming early, 9.5 at. in those flowering at a medium time, and 10.9 at. in those blossoming late. In other words, varieties which flower early are much more sensitive to environmental factors than those which blossom late in the season. This may well be the reason why the period of shoot growth also plays a highly important role in the formation of the following year's flower-buds.

HERRERO (1951) considers the date of leaf abscission to be an important varietal feature, and the colouring of the leaves to be less specific. This statement is confirmed in Table 2, since the yearly fluctuation is much wider in the case of leaf abscission than as regards the beginning of leaf colouring.

As regards these two phenophases the present observations do not agree with those made by TÓTH (1957) for every variety, though in some cases they coincide, e.g. in the case of Montfort, Weisse Königin and Pond's Seedling. The differences can be explained by differences in the growing sites and the experimental methods (Tóth presents absolute, outstanding values, while in the present study seven-year averages for the varieties examined were taken as the basis).

The phenophases of self-fertile, partly self-fertile, practically self-sterile and self-sterile varieties begin at different times. In an earlier paper (SURÁNYI 1980) mention was made of the great differences in phenophases between species and varieties. If the fertilization groups and the taxonomic classification are compared, it is found that varieties which differ with respect to self-fertilization belong to different species and variety groups.

Varieties belonging to the species *Prunus domestica* and *P. insititia* are mostly self-fertile, while *P. cerasifera* is self-sterile. Of the *P. italica* convars the greengages can be either self-fertile or self-sterile; eggplums, date-plums and spillings are mostly self-sterile, while the mirabels may be either self-fertile or self-sterile.

This seven-year series of phenological observations and morphological examinations on the same collection of varieties has provided sufficient data to clarify the taxonomic position of plum varieties. The morphological examinations have now been completed, so the results obtained allow this important subject to be closed.

References

BRÓZIK, S. (1960): Szilva — Kajszi (Plum and apricot varieties). Mezőgazdasági Kiadó, Budapest.

ELEK, L. (1966): Termőrügykialakulás a Jonathán almánál (Development of fruit buds in Jonathan apples). Kert. Szől. Főisk. Közlem., **30**, 89—105.

GARDNER, V. R.—BRADFORD, F. C.—HOOKER, H. D. Jr. (1952): The fundamentals of fruit production. McGraw-Hill, New York—Toronto—London.

HERRERO, J. (1951): Studies of compatible and incompatible graft combinations with special reference to hardy fruit trees. J. Hort. Sci., **26**, 186—237.

HORN, J. (1936): Szilva termesztése (Plum growing). M.K.T.t.T., Budapest.

KEÖPECZY-NAGY, Z. (1943): Gyümölcsfáink különböző fejlődési időpontjai (Entwicklungsetappen der Obstbäume in Ungarn). Magy. Kir. Kert. Szől. Főisk. Közlem., **9**, 95—108.

KOBEL, F. (1954): Lehrbuch des Obstbaums auf physiologischer Grundlage. Springer, Berlin—Göttingen—Heidelberg.

MOSTOLOVITSKA, K. YU.—Мостоловитска К. Ю. (1972): Биология плодоношения сливы в крыму. Вест. сх науки, **17**, 74—78.

NICOTRA, A.—DAMIANO, O.—COBIANCHI, D.—MOSER, L.—FAEDI, W. (1976): Indageni pomologica ed agronomica su 91 varietà di susino. Frutticoltura, **38**, 5—52.

RIEHS, E. (1933): Saugkraftersuchungen an Obstgehölzen. Gartenbauwiss., **7**, 629—638.

RO, L. M. (1929): Trudü cvetocsnüh pocsek i ih razvitie u plodovüh derev'ev za godü 1924—1928. Dokl. Opüt. Stanc. Mleev. 1—99.

SURÁNYI, D. (1980): Morphological and phenological comparative study of plum varieties. Acta Agron. Hung., **28**, 79—89.

TÓTH, E. (1957): Élet- és alaktani összehasonlító vizsgálatok szilvafajtákon (Biologische und morphologische Untersuchungen bei Zwetschensorten). Kert. Kut. Int. Évk., **2**, 11—129.

TÓTH, E. (1967): Adatok szilvafajták termesztési értékének meghatározásához (Contribution to the evaluation of production value in plum varieties). Szőlő- és Gyümölcsterm., **3**, 129—150.

VONDRÁČEK, J. (1975): The study of some phenophases in plums. Acta Hort. Hague, **48**, 23—34.

Acta Agronomica Academiae Scientiarum Hungaricae, Tomus 29 (3–4), pp. 283–289 (1980)

PROGRESS FROM PHENOTYPIC SELECTION IN ALFALFA SELECTED IN SPACED PLANTINGS AND EVALUATED IN SPACED AND DENSE PLANTINGS

I. INDIVIDUAL PLANT SELECTION

By

A. M. RAMMAH, Z. BŐJTÖS

FORAGE CROPS RESEARCH SECTION, FIELD CROPS RESEARCH INSTITUTE, AGRICULTURAL RESEARCH CENTRE, ORMAN, GIZA; AGRICULTURAL RESEARCH INSTITUTE, KOMPOLT

The amount of observed gain in dry matter yield from individual selected plants differed with the system of planting used for evaluating the response to selection and with the system of planting under which the plants were selected. However, gains observed under spaced planting were reduced under drill seeding. Observed gains from progenies tested in spaced planting trials were considerably greater than expected with higher observed gains in close rather than in wide spacing test. All selected genotypes in spaced planting trials failed to maintain their superiority in solid seeding.

Introduction

The masking effect of competition is always a serious problem, mainly because of the preoccupation that the evaluation of genotypes as single plants without competition is abnormal.

Because genotype is always evaluated through its phenotype, much work has been done in order to study the effectiveness of reducing genotype-environment interaction on the efficiency of selection. According to GARDNER (1961) and FASOULAS—TSAFTARIS (1975) the application of highly refined techniques which minimize genotype-environment interaction and make for greater genotypic expression may lead to rapid progress from selection.

Experimental evidence indicates that the effectiveness of selection under non-competitive conditions would be of little value in producing genotypes to be used in solid seeding (WEBER 1957, RADWAN *et al.* 1971, ALI 1971). On the other hand, various authors (HINSON—HANSON 1962, SAKAI *et al.* 1968, CHEBIB *et al.* 1973) have emphasized that competition imposes a marked masking effect which considerably decreases the efficiency of selection.

The aim of this work was to study the effectiveness of one cycle of individual plant selection in improving the yielding ability of alfalfa when selection was applied under competitive and non-competitive conditions.

Material and Method

This study was carried out in the breeding nursery of the Agricultural Research Institute at Kompolt, Hungary. The materials used were open-pollinated seed of four types of alfalfa of diverse genetic origin, represented by erect (C-37), semi-erect (C-244), semi-prostrate (C-636) and prostrate (C-1474) types.

The seeds were sown in seed boxes in the greenhouse in April 1971. The plants were cut at a height of 7 cm and transplanted in June 1971 into three spaced-planted experiments in a randomized complete block design with four replications each. Both plant-to-plant and row-to-row distances were 30, 20, and 10 cm, which will be referred to as wide, medium, and close spacing, respectively. Each type was represented by one row of 10 plants in each replication in the three spaced-planted experiments.

On the basis of the total dry matter yield of three cuts per plant, the highest yielding plant within the row in each of the three spaced experiments was selected. Also the best four plants within each spaced-planted system were selected for each alfalfa type and their seed was mixed in equal quantities to represent mass selecton.

Open-pollinated seed of selected plants and that of the original population from which it was derived were seeded in seed boxes in the greenhouse in October 1972. In May 1973 they were transferred to the experimental field in two single-plant experiments with wide and close spacing, consisting of 5 replications for each type, where each progeny was represented by a 5-plant row in each replication. A mass seeded experiment of 3 replications for each type was also established in a randomized complete block design in April 1973. Forty-nine seeds from each progeny were sown in 30×30 cm plots and thinned to 30 seedlings after complete germination.

Three cuts were taken up till September 1973; the unit of observation was a 5-plant row for the spaced-planted experiments, and the whole plot for the mass seeded experiment. Stand counts were made after each cutting and the yield was expressed as grams of green and dry matter yield.

The gains in dry matter yield expected from individual plant selection were computed from the formula:

$$S = K \cdot H \cdot \delta p$$

where K = the selection intensity when the top 10% of the plants were chosen,

H = the heritability of dry matter yield (on a single plant basis) estimated from variance components under wide, medium and close spacings,

δp = the phenotypic standard deviation of the spaced-planted population subjected to selection.

The observed gains in dry matter yield were computed in each sowing system as

$$\frac{\overline{X}_s - \overline{X}_0}{\overline{X}_0} \times 100$$

where $\overline{X}_s$ = average dry matter yield per plant in the selected population derived from a certain spaced planting trial;

$\overline{X}_0$ = dry matter yield per plant in the original population.

The data of dry matter yield were subjected to a regular analysis of variance by the F-test for each experiment and significance treatments were determined. The significance of the differences between the average plant yields of the four individual plant progenies and the yield per plant in the mass selection treatments was determined by the appropriate "t" test.

Results

The dry matter yield per plant for the progeny of selected individuals, mass selection and the original population was estimated in both solid seeding and spaced planting tests. The data are presented, with F values and LSD, in Table 1. The data showed no significant differences among the progenies

Table 1

Dry matter yield in grams per plant calculated for progeny of selected plants in solid seeding and two spacing nurseries

Planting system of female parent	Progeny no.	Erect			Semi-erect			Semi-prostrate			Prostrate		
		S	C	W	S	C	W	S	C	W	S	C	W
Wide spacing	1	5.2	5.9	30.1	5.5	6.9	17.8	4.8	10.2	31.3	4.5	10.7	16.7
	2	4.2	6.7	30.4	5.8	6.3	22.3	5.4	8.0	30.6	5.3	6.5	15.9
	3	4.6	6.8	29.9	6.2	9.2	31.9	5.2	5.9	27.7	5.7	8.7	15.4
	4	4.7	4.5	23.5	5.6	10.1	36.6	5.3	10.4	22.0	5.6	12.8	17.3
	5	4.5	6.7	29.7	5.5	8.7	31.2	5.3	10.0	31.3	5.4	11.1	17.4
Medium spacing	6	4.6	6.7	32.5	5.8	8.5	27.7	4.8	8.3	26.1	—	3.3	9.0
	7	4.6	7.1	25.4	5.6	8.7	28.8	5.4	8.4	27.2	5.9	9.6	12.6
	8	4.5	7.7	22.7	4.9	11.1	27.2	5.5	10.3	30.2	4.7	7.9	17.0
	9	4.5	5.8	24.6	5.8	10.4	33.1	5.1	7.1	31.5	4.6	6.4	17.1
	10	4.9	9.4	29.9	5.6	9.0	36.2	5.2	7.0	24.6	4.6	7.1	18.0
Close spacing	11	4.2	7.5	27.2	5.0	6.9	30.9	6.8	9.7	35.5	6.2	14.8	13.3
	12	4.8	9.8	34.4	5.5	10.1	31.7	5.5	7.1	29.9	5.9	7.3	11.2
	13	4.9	8.0	28.9	6.1	9.6	24.2	5.3	8.5	26.4	5.9	8.5	15.3
	14	4.2	6.3	31.5	—	7.5	34.4	5.3	11.5	25.0	5.2	6.9	10.9
	15	4.7	9.4	30.3	5.6	6.9	32.0	5.6	9.4	26.6	5.5	5.8	13.7
Orig. population	16	4.4	6.1	27.9	5.6	7.0	32.0	5.6	5.8	36.7	4.9	5.3	10.9
	F value	NS	NS	NS	NS	NS	2.13*	NS	NS	NS	NS	2.3*	4.4**
	LSD						9.88					5.4	4.6

S = solid seeding; C = close spacing; W = side spacing;
*, ** = significant at the 5% and 1% level, respectively.

of selected plants and the original population for the four types of growth habit in the solid seeding test. Similar results were obtained in the close spacing test for erect, semi-erect and semi-prostrate types. For prostrate type, three

Table 2

Observed and expected gains in grams from individual plant selection

Selected female parent	Type of growth	Gains	Sowing system			Average
			Solid seeding	Spaced planting		
				Close	Wide	
Close spacing	Erect	exp.	10.5	10.5	10.5	10.5
		obs.	2.9	33.3	9.3	15.2
	Semi-erect	exp.	6.9	6.9	6.9	6.9
		obs.	−1.2	20.1	−7.0	4.0
	Semi-prostrate	exp.	10.7	10.7	10.7	10.7
		obs.	1.9	59.4	−22.0	13.1
	Prostrate	exp.	11.4	11.4	11.4	11.4
		obs.	18.2	62.3	37.5	39.3
	Average	exp.	9.9	9.9	9.9	9.9
		obs.	5.5	43.8	4.5	17.9
Medium spacing	Erect	exp.	7.5	7.5	7.5	7.5
		obs.	4.9	19.9	−3.1	7.2
	Semi-erect	exp.	6.6	6.6	6.6	6.6
		obs.	−1.3	36.5	−7.6	9.2
	Semi-prostrate	exp.	6.9	6.9	6.9	6.9
		obs.	−7.4	42.5	−3.8	10.4
	Prostrate	exp.	7.4	7.4	7.4	7.4
		obs.	1.4	28.8	32.4	20.9
	Average	exp.	7.1	7.1	7.1	7.1
		obs.	−0.6	31.9	4.4	11.9
Wide spacing	Erect	exp.	8.9	8.9	8.9	8.9
		obs.	5.6	0.5	3.2	3.1
	Semi-erect	exp.	9.5	9.5	9.5	9.5
		obs.	2.2	18.1	−15.0	0.3
	Semi-prostrate	exp.	7.9	7.9	7.9	7.9
		obs.	−7.3	54.1	−22.1	8.2
	Prostrate	exp.	9.1	9.1	9.1	9.1
		obs.	8.9	87.3	49.4	48.5
	Average	exp.	8.8	8.8	8.8	8.8
		obs.	2.3	40.0	3.9	15.0

progenies exceeded the original population in yield (significant at the 5% level); one of the three was derived from the selected female parent in close spacing and the other two belonged to female parents selected in wide spacing.

Significant differences were computed among progenies of semi-erect and prostrate types when the progenies were tested in wide spacings, but all the highest progenies significantly exceeded the original population. For the prostrate type, nine progenies were significantly superior to the original population and only one of the nine was from an individual selected in close spacing.

The expected and observed gains were computed as shown in the Material and Method section, and the values obtained are listed in Table 2. The average observed gain computed over all three spacing trials (last column of Table 2) showed that the progenies of plants selected in close spacing for the erect type gave a 15.2% increase compared to 7.2% and 3.1% for progenies derived from

Table 3

Comparisons of dry matter yield in grams between mean of progenies from selected individuals and that from mass selection, both calculated from the average of solid and spaced sowing

Selected female parents	Type of growth	Individual plant selection		Mass selection
		Range	Mean	
Close spacing	Erect	12.94—16.35	14.29	14.78
	Semi-erect	13.10—17.06	15.52	13.81
	Semi-prostrate	13.13—17.35	14.69	13.85
	Prostrate	10.24—20.88	14.59	12.15
	Average		14.77	13.65
	"t" test		not significant	
Medium spacing	Erect	12.55—14.16	12.55	14.75
	Semi-erect	13.65—16.43	14.72	16.94
	Semi-prostrate	12.67—15.34	14.17	12.24
	Prostrate	12.37—14.30	14.29	12.21
	Average		13.09	14.03
	"t" test		not significant	
Wide spacing	Erect	10.92—14.76	13.04	13.66
	Semi-erect	10.08—18.43	16.82	13.77
	Semi-prostrate	11.98—15.45	13.81	15.61
	Prostrate	13.51—16.40	14.81	15.92
	Average		14.62	14.76
	"t" test		not significant	

parents selected under medium and wide spacings, respectively. Similar results were obtained for the semi-prostrate type.

When the progenies were examined in drill seeding, as a commercial system of production in alfalfa, the observed gains computed for dry matter yield in one cycle of individual plant selection for female parents with close spacing ranged from 2.9% for the erect type to 18.2% for the prostrate type, with an average of 5.5%. The observed gains from progenies of selections with wide spacing ranged from 2.2% for the semi-erect type to 8.9% for the prostrate type, with an average of 2.3%. Both the averages of observed gain were less than that expected on the basis of information from the close spaced--planted nursery. Selection for female parents with medium spacing was not effective in improving the yield of semi-erect and semi-prostrate types, while 4.9% and 1.4% increases compared to the original population were obtained for the erect and prostrate types.

Generally, the observed gains from progenies tested in spaced planting trials were considerably greater than expected, with higher values observed in the close than in the wide spacing test. The progeny of selected female parents with close spacing gave a higher observed gain than those selected in medium and wide spacings, the average increase being 43.8%, 31.9% and 40.0% in the close spacing test and 4.5, 4.4, and 3.9% in the wide spacing test for the progeny of selected parents in close, medium and wide spacings, respectively.

A comparison of the dry matter yield between the mean of progeny from selected individuals and that from mass selection, both calculated from the average of solid and spaced plantings, are listed in Table 3. It can be seen from the data in Table 3 that a wide range of values was obtained for the progeny of individual selection, but the mean was not significantly different from that obtained under mass selection.

Discussion

Remarkable progress was obtained in one cycle of individual plant selection in a population selected for dry matter yield. THEURER—ELLING (1964) and other workers concluded that spaced planting trials are invalid for yield determination in alfalfa. So the amount of observed gain in this work differed with the system of planting used for evaluating the response to selection and with the system of planting under which selection was carried out. None of the superior genotypes selected as single plants without competition maintained their superiority when evaluated in solid stands. Gains observed under spaced planting systems were reduced under solid seeding.

Thus, it may be concluded that the lack of effective selection in wide spacing from a large population when the progeny of selected plants were tested in solid seeding mainly resulted in dismissing the evaluation for the competitive ability of selected genotypes, which may introduce a new source of non-genetic variation into the selection nursery due to larger nursery size and local environmental differences (PARKER 1931).

Selecting the highest yielding plant without taking into account the situation of the neighbouring plants surrounding this plant may result in the failure of mass selection. FASOULAS—TSAFTARIS (1975) concluded that soil heterogeneity has the greatest significance during the early selection stages, when a number of genotypes must be screened, each having a unique genetic constitution. So an accurate measurement of different sources of variation, taking into account the competitive ability of the plant, will lead forage breeders to a better design of the selection nursery.

References

ALI, F. M. (1971): The effect of mass selection on forage yield and related traits in berseem clover (*Trifolium alexandrinum* L.). M. Sc. Thesis, Faculty of Agriculture, Univ. of Cairo, Egypt.

CHEBIB, F. S.—HELGASON, S. B.—KALTSIKES, P. J. (1973): Effect of variation in plant spacing, seed size and genotypes on plant-to-plant variability in wheat. Z. Pflanzenzüchtg., **69**, 301—332.

FASOULAS, A.—TSAFTARIS, A. (1975): An integrated approach to plant breeding and field experimentation. Dept. Gen. Pl. Breeding, Aristotelian Univ. of Thessaloniki, Greece. Public. No. 5.

GARDNER, C. O. (1961): An evaluation of effects of mass selection and seed irradiation with thermal neutrons on yield of corn. Crop Sci., **1**, 241—245.

HINSON, K.—HANSON, W. D. (1962): Competition studies in soybeans. Crop Sci., **2**, 117—123.

PARKER, W. H. (1931): Methods employed in variety trials by the National Institute of Agricultural Botany. Aust. J. Agr. Bot., **3**, 5—22.

RADWAN, M. S.—FARID, N. L.—RAMMAH, A. M.—MOSTAFA, M. (1971): Progeny testing in berseem (Egyptian clover), *Trifolium alexandrinum* L. Z. Pflanzenzüchtg., **66**, 235—238.

SAKAI, K. L.—MUKAIDE, H.—TOMITA, K. (1968): Intraspecific competition in forest trees. Silves Genetica, **17**, 1—5.

THEURER, J. C.—ELLING, L. J. (1964): Comparative performance of diallel crosses and related second-generation synthetics of alfalfa, *Medicago sativa* L. III. Forage yield. Crop Sci., **4**, 25—28.

WEBER, C. R. (1957): Selection for yield in bulk hybrid soybean population with different plant spacings. Agron. J., **49**, 547—548.

Acta Agronomica Academiae Scientiarum Hungaricae, Tomus 29 (3–4), pp. 291–296 (1980)

CHANGES IN PROTEIN CONTENT AND PHOSPHOMONOESTERASE AND PHOSPHODIESTERASE ACTIVITIES IN CALLUS TISSUES OF SOME SCION AND STOCK VARIETIES OF VINE

By

M. K. Szabó, J. Udvardy, P. Kozma, D. Polyák

UNIVERSITY OF HORTICULTURE, DEPARTMENT OF VINE GROWING, BUDAPEST;
HUNGARIAN ACADEMY OF SCIENCES, INSTITUTE FOR PLANT PHYSIOLOGY OF THE SZEGED BIOLOGICAL CENTRE, SZEGED

In basal and apical callus tissues from four scion varieties (Olasz rizling, Rizlingszilváni, Hárslevelű and Kékfrankos) and three stock types (SO 4, 5BB and 5C) of vine the protein content, phosphomonoesterase and phosphodiesterase were determined every two weeks from January to June. As regards protein content, only the variety Rizlingszilváni and the stock-type 5BB showed changes of a similar tendency in the callus tissues during the period from January to June. The change in protein level in the other scion varieties and stock types examined proved to be of antiparallel character. At the beginning of the vegetation period the protein level in the basal calluses of scion varieties was always much higher than in the corresponding apical calluses. Changes in the phosphomonoesterase and phosphodiesterase enzyme levels of scion varieties and stock-types showed considerable differences in the period from April to June.

Introduction

The mass production of vine grafts under farm conditions represents a difficult task in practice and theory alike.

Proper callus formation is one of the preconditions of successful graft production (Zilai 1966, Schenk 1976). Our research team has recently included enzyme examinations in the callus research programme (Kozma *et al.* 1979). The present paper gives an account of some of the results achieved.

It is a well-known fact that certain practical problems can be traced back to insufficient knowledge of the physiological processes taking place when the vine is dormant. For instance, hardly anything is known about the enzymatic changes taking place in the plant tissues during the winter period.

The problem may be connected with numerous fields of practice. It is known, for example, that the yield percentage of vine grafts is very low. If the joining of the stock and scion is deficient or does not occur at all, this is attributed by many authors to the meristematic incompatibility of the graft components. Besides anatomical and histological factors, however, the concept of incompatibility includes the physiological and biochemical harmony or dis-harmony of the graft components, a question to which little attention has been paid so far.

The complete fusion of the protoplasms of the stock and scion is an indispensable condition for successful graft production. The process takes place at the meristematic level, through callus formation between the two cut surfaces. Hormone synthesis and the induction of a number of hydrolytic enzymes, both of them occurring in response to the injury, are welk-known phenomena. However, no data are available as yet on the enzymatic changes which precede and attend the activity of the fusing protoplasms of vine callus cells.

As a first approach to the problem, knowledge must be acquired of the enzymes present in the tissues of the graft components and of the qualitative and quantitative changes which take place in the enzymes before and after grafting. This was the aim of the investigations described in this paper.

The question to be answered was: what similarity or difference is shown by the basal and apical meristems of scion and stock varieties in the state of dormancy and in the first period of vegetation, as regards protein synthesis and the activities of certain nucleic acid-decomposing enzymes.

Material and Method

Comparative studies were made with callus cells from four scion varieties (Olasz rizling, Rizlingszilváni, Hárslevelű and Kékfrankos) and from the clones Berlandieri×Riparia T. K. 5BB, Berlandieri×Riparia T. 5C and Berlandieri×Riparia SO 4, which were used as rootstocks.

In order to induce callus formation 6—8 cm long internodes of vine shoots were placed in sterilized plastic boxes between layers of wet filter paper every two weeks from January to the end of June. In a thermostat at 28°C callus was formed on the apical and basal cut surfaces of the shoots in two weeks.

After two weeks the amorphous mass of callus formed on the surface of the wound was removed with a scalpel, weighted and washed in tap water. The soluble cell content was extracted from the material thus obtained.

The cells were homogenized in a mortar with quartz sand in 0.05 M Tris-HCl buffer (pH 7.5) containing 0.1% ascorbic acid. The suspension was centrifuged at 8,000 g for 20 minutes. The protein content and the phosphomonoesterase and phosphodiesterase activities were determined from the supernatant.

The protein content was determined with Folin reagent according to LOWRY *et al.* (1951). As a standard, bovine serum albumin was used. Synthetic substrates of p-nitrophenyl-phosphate were used in measuring the phosphomonoesterase activity and of bis-p-nitrophenyl-phosphate for demonstrating the phosphodiesterase activity. The final products of the enzyme reactions were measured with a spectrophotometer at 400 millimicrons (UDVARDY *et al.* 1970, WYEN *et al.* 1971).

Results

The change in the soluble protein content is one of the characteristic indices of active metabolism. An increase in the components of the protoplasm and the preparations for cell division are always preceded by intensive protein synthesis.

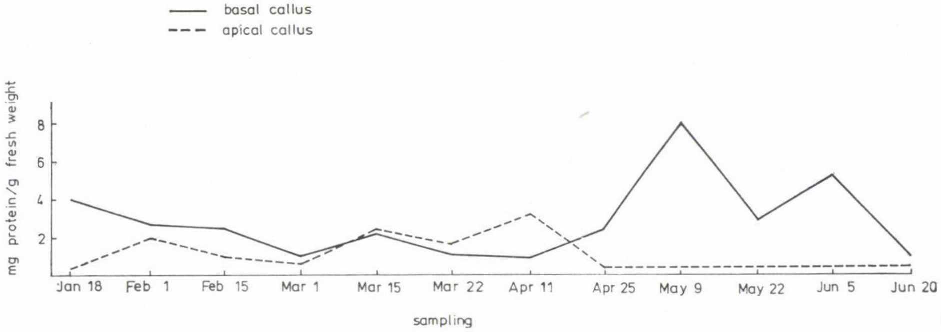


Fig. 1. **Soluble protein contents of callus tissues formed at the apical and basal poles of Olasz-rizling shoots, mg, 1978**

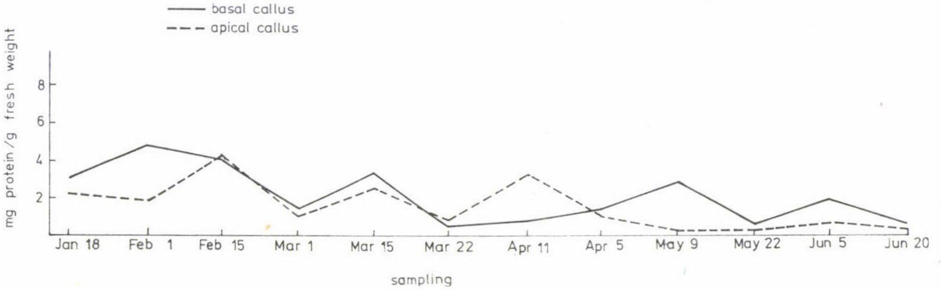


Fig. 2. **Soluble protein contents of callus tissues formed at the apical and basal poles of Riz-lingszilváni shoots, mg, 1978**

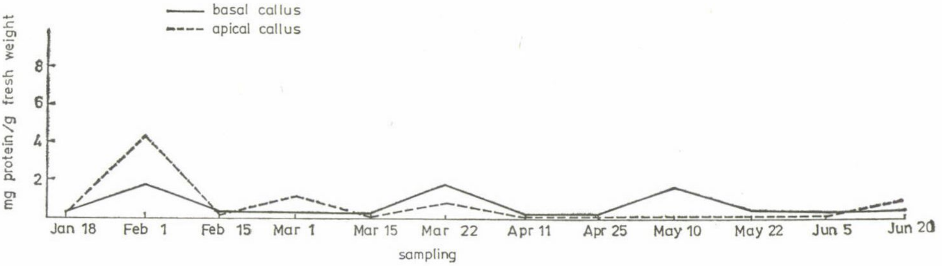


Fig. 3. **Soluble protein contents of callus tissues formed at the apical and basal poles of 5BB shoots, mg, 1978**

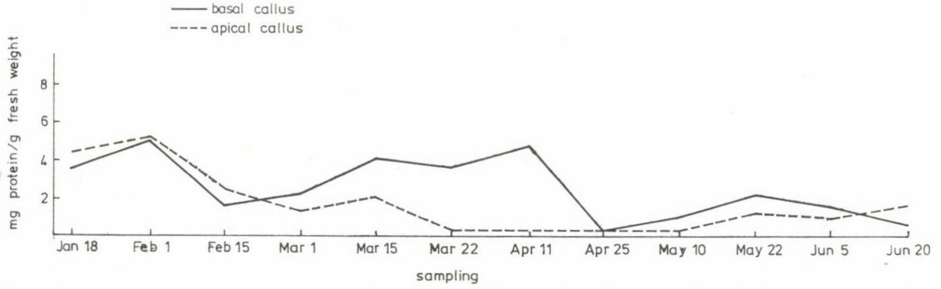


Fig. 4. **Soluble protein contents of callus tissues formed at the apical and basal poles of SO 4 shoots, mg, 1978**

The protein content of the callus formed at the apical and basal poles of the Olasz rizling shoot hardly changed from the end of January to late in April; its value ranged between 1 and 3 mg protein per 1 g fresh weight, as seen in Fig. 1. At the beginning of the intensive vegetation period the protein synthesis in the basal callus became 4—5 times greater, but slowed down at the end of June. In the same period a minimum (0.1—0.2 mg/g fresh weight) amount of protein was found in the apical callus. It is worth noting that in Hárslevelű and Kékfrankos the changes were of a similar nature.

As for the changes in the protein level of Rizlingszilváni, it was noticeably different in character from those of the former types (Fig. 2). From January to June the protein content showed a uniform, slightly decreasing tendency. At the beginning of the intensive vegetation period, in early summer, no rise in the protein level of the basal callus was found. In May and June the protein synthesis in the apical callus was reduced in this case too.

The rootstock 5BB shows the same character (Fig. 3).

In rootstock SO 4 the protein-synthesizing activity of the root and shoot poles remained intensive until the end of April, then lessened in May and June. The changes are shown in Fig. 4. The same character was found for rootstock 5C.

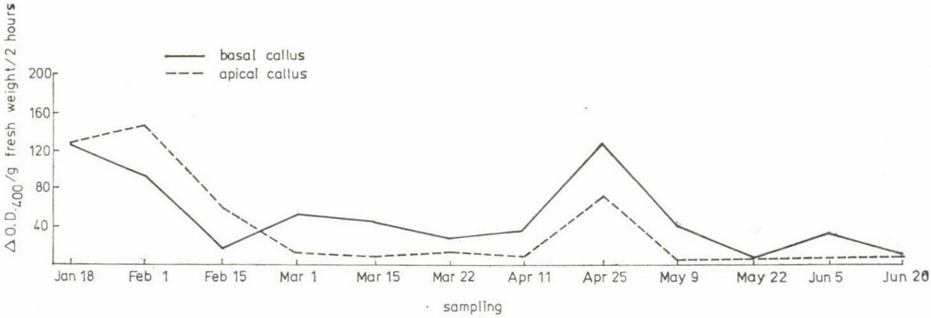


Fig. 5. **Phosphomonoesterase activities in callus tissues formed at the apical and basal poles of Hárslevelű shoots, 1978**

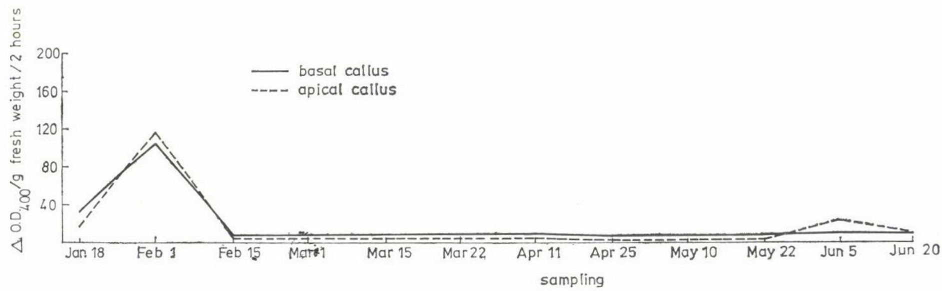


Fig. 6. **Phosphomonoesterase activities in callus tissues formed at the apical and basal poles of 5C shoots, 1978**

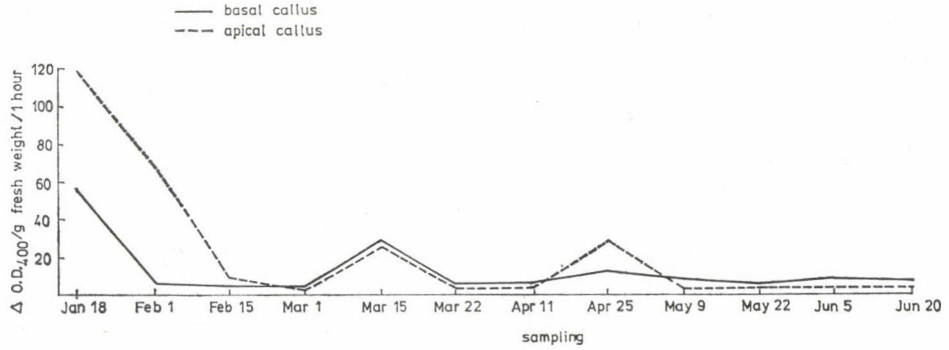


Fig. 7. **Phosphodiesterase activities in callus tissues formed at the apical and basal poles of Rizlingszilváni shoots, 1978**

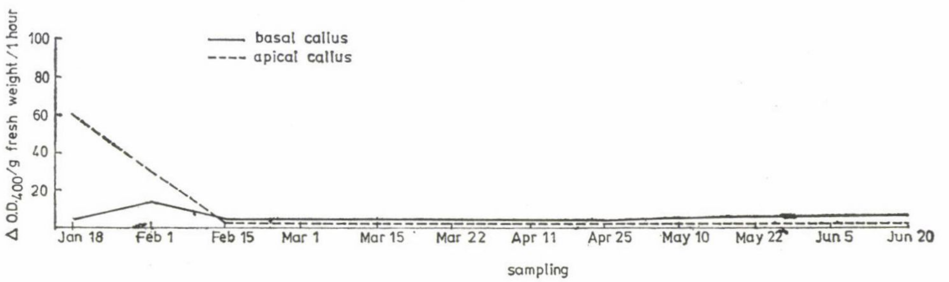


Fig. 8. **Phosphodiesterase activities in callus tissues formed at the apical and basal poles of 5BB shoots, 1978**

Enzyme proteins catalysing the hydrolytic and synthetic processes of the cell metabolism are highly reactive to the endogenous rhythm of the living organism. In many cases a qualitative or quantitative enzyme induction may also occur under the influence of pathogens or on changes in the ecological and development factors (FILNER *et al.* 1969, MARCUS 1971). The activity of the phosphomonoesterase and phosphodiesterase taking part as "markers" in the transformation of nucleic acid intermediaries was followed from this point of view.

In the apical and basal callus tissues of Hárslevelű very high values of phosphomonoesterase activity were measured in January. At the end of April the enzyme activity increased again. The changes are shown in Fig. 5. This is probably an indicator of energy mobilization processes related with bud bursting. In June the enzyme activity in the basal callus was still intensive, while in the apical callus the enzyme level was already lower. Changes of a similar character were found in the callus tissues of Olasz rizling, Rizlingszilváni and Kékfrankos.

As regards the changes in the enzyme level of rootstock 5C, they were noticeably different from those in the scion varieties (Fig. 6). Intensive enzyme activity was measured only in January. Subsequently the enzyme level fell practically to zero, and it was only at the end of June that it again showed a slight increase. The same one-peak curve for phosphomonoesterase activity is characteristic of the callus tissues of the other two rootstock types examined: SO 4 and 5BB.

In the callus tissues of Rizlingszilváni increased phosphodiesterase activity was observed at the beginning of January, in mid-March and in late April. The changes in the enzyme activity are shown in Fig. 7. In May and June the enzyme level fell sharply. Olaszrizling, Hárslevelű and Kékfrankos shoots showed similar patterns of enzyme activity.

The enzyme spectra of 5BB differs from those of the scion varieties in that the only maximum is in January (Fig. 8). During the rest of the period examined the phosphodiesterase activity was very low. Similar trends are shown by the rootstocks SO 4 and 5C.

References

FILNER, P.—WRAY, J. L.—VARNER, J. E. (1969): Enzyme induction in higher plants. Environmental or developmental changes cause many enzyme activities of higher plants to rise or fall. Science, **165**, 358—367.

KOZMA, P.—POLYÁK, D.—SZABÓ, M. K.—UDVARDY, J. (1979): Purification and properties of a phosphodiesterase and nucleotide pyrophosphatase from root callus tissues of vine shoots. Acta Agron. Hung., **28**, 281—294.

LOWRY, O. H.—ROSEBROUGH, N. J.—FARR, A. L.—RANDALL, R. J. (1951): Protein measurement with the Folin fenol reagent. J. Biol. Chem., **193**, 265—275.

MARCUS, M. (1971): Enzyme induction in plants. Ann. Rev. Plant Physiol., **22**, 313—336.

SCHENK, W. (1976): Einfluss der Dorsiventralität und Polarität auf die Kallusbildung und Verwachsung der Propfreben, insbesondere im Hinblick auf die Maschinenveredlung. Weinberg u. Keller, Traben-Trarbach., **23/3**, 89—112.

UDVARDY, J.—MARRE, E.—FARKAS, G. L. (1970): Purification and properties of a phosphodiesterase from Avena leaf tissues. Biochim. Biophys. Acta, **206**, 392—403.

WYEN, N. V.—UDVARDY, J.—FARKAS, G. L. (1971): Changes in the level of acid phosphatases in Avena leaves in response to cellular injury. Phytochemistry, **10**, 765—770.

ZILAI, J. (1966): A szőlővessző kalluszképzésének tanulmányozása (Study on callus formation in vine shoots). MTA IV. Oszt. Közl., **25**, 291—307.

VARIA

GROWTH OF TWO MELILOTUS SPECIES (M. ALBUS DESR. AND M. DENTATUS (W. ET K.) PERS.)

From the point of view of improving the fodder supply the use of *Melilotus* species is promising in Hungary as elsewhere. The cultivation of *Melilotus* in Hungary was first urged by GYÁRFÁS (1922), who found it particularly suitable for replacing other papilionaceous crops where those could no longer be grown. Since the thirties its production area has varied between 3000 and 5000 ha. It has been sown for soil conservation rather than for feeding purposes. It can be used for feeding equally well when fresh, as hay and in the form of silage. Although it is not always accepted readily by the animals owing to its coumarin content, once they are accustomed to it, it produces good results. According to SUVOROV (1950) the quality of melilot, if it is cut at the correct time, is equal to that of red clover and lucerne, and its digestibility is not inferior either. Owing to its high protein content it can be used to increase the protein concentration of feeds (BÁRDOSSY 1961). According to WHEELER (1950), on soils where papilionaceous plants have not previously been included in the crop rotation there is no crop better than melilot for restoring the fertility of the soil. It is a good honey-bearing plant (PÉTER 1972) and can be successfully used to check erosion and to cover banks.

Since nothing had so far been reported on the growth of melilot, the growth of *Melilotus albus* and *M. dentatus* were studied in 1977. Hungarian bred cultivars of both species were examined; they can be briefly characterized as follows:

Table 1

Soil characteristics of the experimental sites

Experimental site	Soil layer, cm	$CaCO_3$, %	Humus, %	pH		hy
				H_2O	KCl	
Mosonmagyaróvár	0—20	19.0	3.87	7.6	7.6	2.50
	20—40	22.4	3.28	7.2	7.2	2.40
	40—80	15.6	1.77	7.2	7.0	2.50
	80—100	8.8	1.43	7.2	6.9	2.60
	100—140	27.8	0.33	7.8	7.8	0.80
Kecskemét	0—20	0.7	1.35	7.9	6.8	0.70
	20—70	0.0	0.78	7.7	7.0	0.69
	70—100	6.4	0.97	7.6	6.9	1.50
	100—120	29.4	0.59	7.5	6.5	1.14

M. albus cv. 'Kecskeméti kétéves fehérvirágú' selected from a Kisújszállás local variety is a cultivar with good overwintering ability. Its breeding was started in 1955 by Ferenc Bauer and Ernő Hammer and it was state registered in 1969. It is a steady biennial cultivar with good productivity, characterized by a medium fine, long stalk and vigorous growth. It outyields the earlier commercial varieties, but its coumarin content is not significantly lower.

Table 2

Meteorological data

Date of sampling (1977)	Average temperature (°C)	Precipitation (mm)	Number sunshine hours
Mosonmagyaróvár			
21 March – 28 March	13.4	—	51
28 March – 5 April	6.1	24	32
5 April – 12 April	6.5	25	35
12 April – 18 April	5.6	4	43
18 April – 25 April	10.1	1	44
25 April – 2 May	14.0	7	42
2 May – 9 May	16.7	24	38
9 May – 16 May	13.1	4	46
16 May – 23 May	16.6	11	37
23 May – 30 May	11.9	—	80
30 May – 6 June	13.7	2	61
6 June – 13 June	19.6	7	69
13 June – 20 June	22.2	2	68
20 June – 27 June	18.7	7	51
27 June – 4 July	18.6	—	49
4 July – 11 July	20.1	7	46
11 July – 18 July	19.6	19	55
18 July – 25 July	18.2	14	56
25 July – 31 July	19.4	1	39
1 August – 9 August	19.2	8	50
Kecskemét			
22 March – 6 April	9.9	20	72
6 April – 19 April	7.3	15	63
19 April – 3 May	13.5	8	108
3 May – 17 May	15.8	28	77
17 May – 31 May	15.7	—	131
31 May – 15 June	18.1	—	148
15 June – 28 June	21.1	30	105

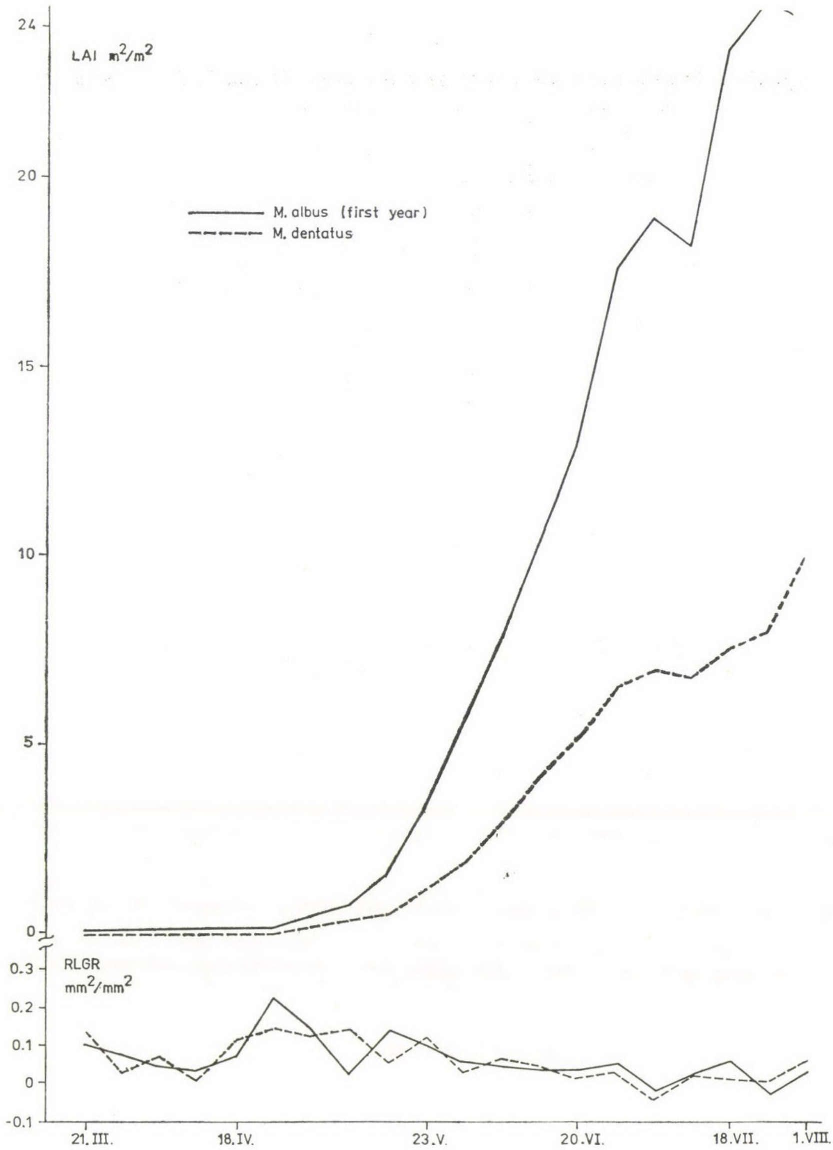


Fig. 1. Changes in the RLGR and LAI of first year *M. albus* and *M. dentatus* in the growth season

The cultivar is particularly suitable for improving calcareous sandy soils and for fixing the surface of the land.

M. dentatus cv. 'Szarvasi sárgavirágú' is a cultivar developed at the Research Institute for Irrigation, Szarvas, from a Chinese basic population; it was state registered in 1974. The breeder was Gábor Kovács. (Although the National Agricultural Variety Testing Institute [OMFI] places it with the species *M. officinalis* Lam., it undoubtedly belongs to *M. dentatus*.)

Table 3

Equations for weight increase in first year M. albus (1) and in M. dentatus (2)

Phase	Equation
I	$Y = 0.002089\ e^{0.0732X}$ (1)
	$Y = 0.002137\ e^{0.0704X}$ (2)
II	$Y = 0.005495\ e^{0.0272X}$ (1)
	$Y = 0.005754\ e^{0.0267X}$ (2)
III	$Y = 0.016218\ e^{0.1015X}$ (1)
	$Y = 0.008709\ e^{0.1057X}$ (2)
IV	$Y = 3.8904\ e^{0.0281X}$ (1)
	$Y = 2.6302\ e^{0.0235X}$ (2)

Y = number of days; X = g

Table 4

Changes in the growth parameters of first year M. albus
(Mosonmagyaróvár, 1977)

Date of sampling (1977)	RGR g/g/day			NAR $\times 10^{-4}$ g/mm²/day	LAR mm²/g	CGR stem + leaf g/day
	Root	stem + leaf	Total			
21 March — 28 March	0.1181	0.0770	0.0920	0.1831	5,081.9	0.0001
28 March — 5 April	0.0898	0.0398	0.0568	0.0988	5,825.2	0.0001
5 April — 12 April	−0.0811	0.0565	0.0066	0.0092	7,286.8	0.0002
12 April — 18 April	0.0095	−0.0105	−0.0051	−0.0055	9,230.8	−0.00005
25 April — 2 May	0.1038	0.1972	0.1786	0.1508	12,617.2	0.0036
2 May — 9 May	0.1309	0.1317	0.1316	0.0921	14,506.4	0.0073
9 May — 16 May	0.0411	0.0368	0.0375	0.0259	14,386.9	0.0036
16 May — 23 May	0.0579	0.1229	0.1146	0.0729	16,166.6	0.0214
23 May — 30 May	0.2038	0.1264	0.1367	0.0907	14,631.6	0.0528
30 May — 6 June	0.0741	0.1120	0.1064	0.0964	10,665.2	0.1071
6 June — 13 June	0.1210	0.0682	0.0764	0.0933	8,069.9	0.1207
13 June — 20 June	0.0165	0.0343	0.0313	0.0413	7,592.3	0.0864
20 June — 27 June	0.0630	0.0404	0.0443	0.0599	7,367.7	0.1321
27 June — 4 July	0.0598	0.0660	0.0649	0.0973	6,620.9	0.3150
4 July — 11 July	0.0116	0.0113	0.0113	0.0204	5,571.1	0.0700
11 July — 18 July	0.0582	0.0129	0.0222	0.0466	4,745.2	0.0871
18 July — 25 July	0.0592	0.0418	0.0460	0.0967	4,771.6	0.3428
25 July — 1 August	0.0061	−0.0324	−0.0216	−0.0464	4,677.1	−0.2743
1 August — 8 August	0.0295	0.0520	0.0454	0.1088	4,154.6	0.4728

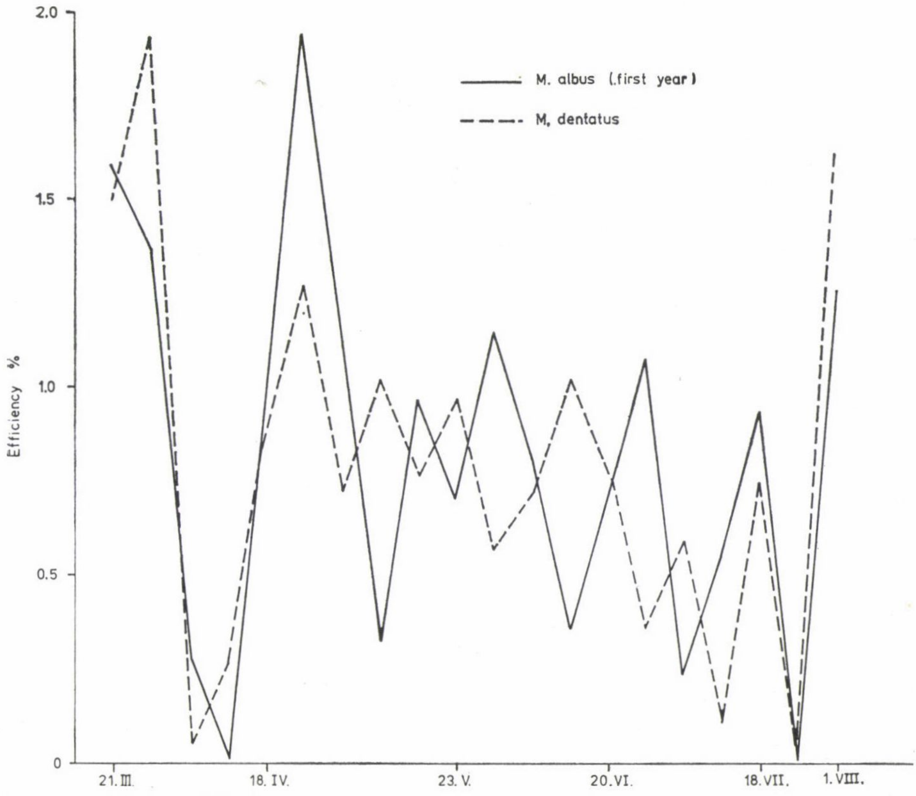


Fig. 2. **Changes in the efficiency of first year *M. albus* and *M. dentatus* in the growth season**

It is an annual, medium high, green stalked, large leaved cultivar. It has medium green dentate leaves. As regards productivity it is inferior to the previously described cultivar, but contains considerably less coumarin. It is primarily worth producing for feeding purposes.

The growth of the stands was observed at Mosonmagyaróvár for *M. dentatus* and for first year *M. albus*, and at Kecskemét for second year *M. albus*. The soil characterization and the meteorological data of the experimental sites are contained in Tables 1 and 2.

The dates of sample taking are given in Table 2. The plants were removed from a depth of 20 cm. The plant number per m^2 was 450 for *M. albus* (first year), 280 for *M. dentatus* and 140 for *M. albus* (second year). Shoots (stalk + leaf) and roots were weighed separately, after drying at 80°C. The leaf area was determined by measuring on graph paper 5 lower, 5 medium and 5 upper leaves of a plant with average development and by weighing the leaves. From the weight of the total leaves of the plant the total leaf area was calculated. The leaf area values refer to one side of the leaf blade.

Of the growth characters the RGR, NAR, LAR, RLGR, LAI and CGR are given. RGR is given for root (RGR_{root}), stem + leaf (RGR_{stem}) and root + stem + leaf (RGR_{total}), while CGR is only given for stem + leaf. Efficiency was examined by the method described by Précsényi *et al.* (1977).

First year growth. In the increase of total weight (per plant) of *M. albus* and *M. dentatus* four phases were distinguished: phase I: 21st March—5th April; phase II: 5th April—25th April; phase III: 25th April—20th June; phase IV: 20th June—8th August.

Table 5

Changes in the growth parameters of M. dentatus
(Mosonmagyaróvár, 1977)

Date of sampling (1977)	RGR (g/g/day)			NAR × 10⁻⁴ g/mm²/day	LAR mm²/g	CGR stem + leaf g/day
	Root	stem + leaf	Total			
21 March — 28 March	0.0769	0.0730	0.0742	0.1591	4.915.2	0.0001
28 March — 5 April	0.1373	0.0142	0.0684	0.1413	4.752.5	0.00004
5 April — 12 April	−0.0521	0.0509	0.0022	0.0040	5.581.4	0.0002
12 April — 18 April	−0.0372	0.0469	0.0193	0.0282	6.847.8	0.0002
18 April — 25 April	0.0007	0.0756	0.0598	0.0074	8.342.4	0.0005
25 April — 2 May	0.0847	0.1169	0.1113	0.1042	11.019.8	0.0016
2 May — 9 May	0.1167	0.0687	0.0774	0.0593	13.282.7	0.0018
9 May — 16 May	0.1055	0.1283	0.1238	0.0795	15.939.8	0.0068
16 May — 23 May	0.0681	0.0945	0.0901	0.0610	14.480.7	0.0108
23 May — 30 May	0.1038	0.1520	0.1455	0.1186	12.022.8	0.0426
30 May — 6 June	0.0411	0.0542	0.0527	0.0478	10.973.8	0.0300
6 June — 13 June	0.0747	0.0801	0.0795	0.0780	10.131.5	0.0714
13 June — 20 June	0.0963	0.0948	0.0949	0.1181	7.804.5	0.1567
20 June — 27 June	0.0247	0.0434	0.0415	0.0657	6.290.5	0.1147
27 June — 4 July	0.0444	0.0175	0.0202	0.0316	6.432.2	0.0571
4 July — 11 July	0.0244	0.0308	0.0301	0.0533	5.646.4	0.1193
11 July — 18 July	0.0108	0.0042	0.0049	0.0100	4.957.4	0.0185
18 July — 25 July	0.0216	0.0387	0.0369	0.0777	4.727.9	0.1971
25 July — 1 August	−0.0216	−0.0026	−0.0045	−0.0100	4.485.6	−0.0150
1 August — 8 August	0.0344	0.0627	0.0605	0.1319	4.586.7	0.4493

Table 6

Correlations between the growth parameters of first year M. albus and M. dentatus
(Mosonmagyaróvár, 1977)

Growth parameter	r
RGR root	0.630**
stem + leaf	0.585**
total	0.672**
NAR	0.625**
LAR	0.956***
RLGR	0.592**
LAI	0.998***
CGR stem + leaf	0.919***

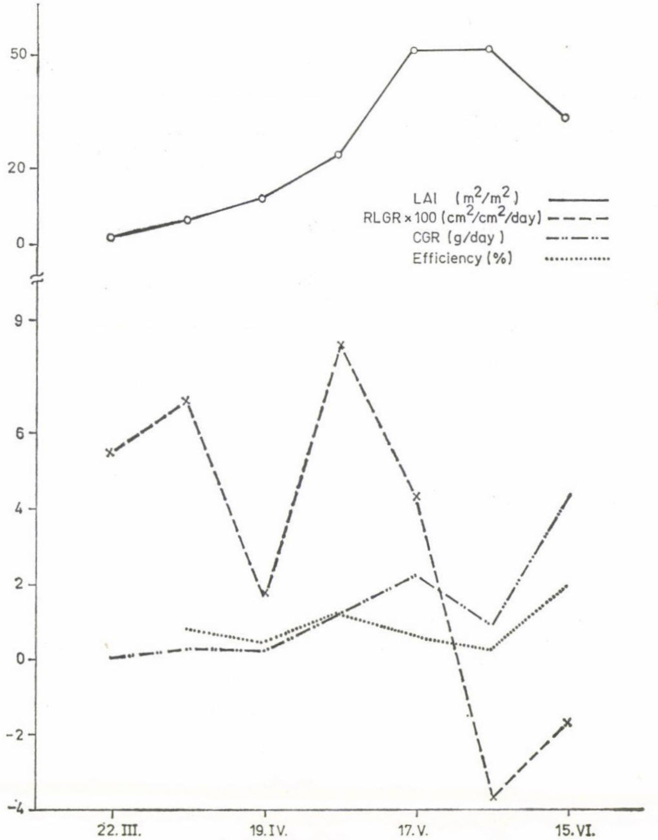


Fig. 3. Changes in the LAI, RLGR, CGR and efficiency of second-year *M. albus* in the growth season

In phases I, II and IV, as can be seen in Table 3, *M. albus* showed a somewhat faster weight increase than *M. dentatus*, though the exponents are very close to one another.

LAR and CGR in *M. albus* are higher than in *M. dentatus*. As regards leaf area per plant *M. albus* exceeds *M. dentatus* in every case. When LAI is taken into account the difference in favour of *M. albus* is even greater, owing to the difference in plant number (Tables 4 and 5; Fig. 1).

In first year *M. albus* and in *M. dentatus* close positive correlations were found between LAI, LAR and $CGR_{stem+leaf}$. Correlations between the other characters, while also positive, were less close (Table 6). For the other features examined there was no difference between the two species.

Of the climatological factors the average temperature was in positive significant correlation with LAI and CGR. LAI showed a somewhat closer correlation with the average temperature (0.8) than CGR (0.6—0.7). A significant positive correlation was also found between CGR and the average number of sunshine hours. The other growth parameters examined showed no correlation with the climatological factors studied. (The negative correlation between the RLGR of *M. albus* and the average temperature hardly reached the 5% level of significance; Table 7).

Table 7

Correlations between growth

	Climatic factor	RGR Root	RGR stem + leaf	RGR Total
Melilotus albus (first year)	°C	−0.006	−0.255	−0.203
	mm	−0.162	−0.088	−0.176
	h	—	−0.050	0.052
Melilotus dentatus (first year)	°C	−0.034	−0.116	−0.072
	mm	−0.059	−0.264	−0.171
	h	—	0.206	0.167
Melilotus albus (second year)	°C	0.464	−0.321	−0.071
	mm	0.500	0.286	0.232
	h	—	−0.178	0.036

°C = mean temperature
mm = amount of precipitation
h = average number of sunshine hours

First year *M. albus* and *M. dentatus* hardly differ in average efficiency (Fig. 2).

Second year growth of *M. albus.* In the case of second year *M. albus* phases were not distinguished in the total weight increase (partly because of the small number of samples). The weight increase can be expressed by the equation $Y = 2.215e^{0.0423x}$. Of the climatological

Table 8

Growth parameters of second year M. albus
(Kecskemét, 1977)

Date of sampling	RGR (g/g/day) Root	RGR (g/g/day) stem + leaf	RGR (g/g/day) Total	NAR × 10⁻⁴ (g/mm²/day)	LAR (mm²/g)
22 March — 6 April	−0.0260	0.0292	0.0000	0.0000	6.038.71
6 April — 19 April	0.0105	0.0802	0.0580	0.0641	9.203.31
19 April — 3 May	0.0334	0.0327	0.0328	0.0387	8.365.41
3 May — 17 May	0.0452	0.0795	0.0727	0.0887	8.365.54
17 May — 31 May	0.0262	0.0578	0.0535	0.0671	7.850.77
31 May — 15 June	0.0055	0.0141	0.0132	0.0257	5.281.12
15 June — 28 June	0.0477	0.0448	0.0451	0.1967	2.237.77

factors, the average number of sunshine hours was in close positive correlation with LAI, and the average temperature with LAI and CGR. None of the other growth characters examined showed any correlation with the climatological factors considered (Table 7). The parameters for the second year's growth are shown in Table 8 and Fig. 3.

The average efficiency is about the same for second year *M. albus*, first year *M. albus* and *M. dentatus.*

parameters and climatic factors

NAR	LAR	RLGR	LAI	CGR stem + leaf
−0.016	−0.406	−0.455*	0.815***	0.637**
−0.079	−0.115	0.018	−0.025	0.095
0.107	−0.066	−0.198	0.360	0.555*
0.049	−0.243	−0.345	0.821***	0.678***
−0.059	−0.143	−0.206	−0.011	0.052
0.261	0.022	−0.079	0.369	0.607**
0.464	−0.750	−0.678	0.857*	0.786*
0.482	0.071	0.339	−0.411	0.178
0.321	−0.428	−0.643	0.928**	0.678

* = significant at the 5% level
** = significant at the 1% level
*** = significant at the 0.1% level

Acknowledgements

We are indebted to Mr. Ferenc Bauer, scientific head of section, and Mr. Ernő Hammer, senior research worker (Research Institute for Vegetable Crops, Kecskemét) for making it possible for us to study the melilot stands at Kecskemét, and for assisting us with their useful advice.

*

Prepared at the Department of Botany and Plant Physiology of the Mosonmagyaróvár Faculty of the Keszthely University of Agricultural Sciences, and at the Research Institute for Botany of the Hungarian Academy of Sciences, Vácrátót.

GY. CZIMBER, I. PRÉCSÉNYI

References

BÁRDOSSY, A. (1961): Adatok az édes szudáni cirokfű és pillangós növények társított termesztéséhez (Combined growing of sweet Sudan grass and papilionaceous crops). Mosonmagyaróvári Mezőgazd. Akad. Közlem., **4**, 85–94.

GYÁRFÁS, I. (1922): Magyar dry-farming. Sikeres gazdálkodás szárazságban (Dry-farming in Hungary. Successful farm management under dry conditions). Pátria, Budapest, 83–84.

PÉTER, J. (1972): A szántóföldi növények mézeléséről (Honey production by field crops). Méhészet, **20**, 147.

PRÉCSÉNYI, I.—CZIMBER, GY.—CSALA, G. (1977): Light energy transformation in maize hybrids. Acta Agron. Hung., **26**, 135–140.

SZALAY, M. (1967): Biológia a mérnöki gyakorlatban (Biology in the practice of engineering). Műszaki Könyvkiadó, Budapest.

SUVOROV, V. V. (1950): Melilotus (Tourn.) Adans. Em. Kulturnaya Flora SSSR XIII. Moscow—Leningrad, **1**, 345–502.

VARGA, J. (1966): A fehérvirágú somkóró. In: LÁNG G.: A növénytermesztés kézikönyve 2. (White melilot. In: LÁNG, G.: Handbook for crop growing 2.). Mezőgazdasági Kiadó, Budapest.

WHEELER, W. A. (1950): Sweetclover. Forage and Pasture Crops. D. Van Nostraud Company, New York, **752**, 340–359.

EVOLUTION OF WHEAT (TRITICUM L.) IN RESPECT TO RECENT RESEARCH

As is well known, there are many cultivated varieties of common wheat (T. *aestivum* L.), but its evolutionary genetics is not completely clear. At present it is not certain which diploid species are involved in the synthesis of this hexaploid wheat, and how the genomes of the progenitor species have changed during evolution.

Systematicists have determined that the donor of genome A in hexaploid wheat is a diploid wheat. Earlier *T. monococcum* ssp. *boeoticum* was considered to be the most ancient wheat, but now it is supposed that *T. urartu* is the oldest. Caryologically *T. urartu* does not differ considerably from the other diploid wheats (GIORGI—BOZZINI 1969), but the protein patterns were demonstrated to be different (JOHNSON 1975, KONAREV 1975, KONAREV—PENEVA 1975). Similarly to the results of JAASKA (1974) with electrophoresis on polyacrylamide gels (PAGE), the authors also found certain differences in the esterase spectra obtained by analytical isoelectrofocussing (IEFPA) (Fig. 1). This finding is also supported by the heterochromatic staining technique (HCST) used in our laboratory, that greatly enhances chromosome identification.

The dissimilar banding of the chromosomes implies that the formation of *T. urartu* and *T. monococcum* ssp. *boeoticum* was a parallel process. According to GUBAREVA *et al.* (1975), genome A in *T. timopheevi* originated from *T. monococcum* ssp. *boeoticum* and the source of genome A in other tetraploid wheats is *T. urartu* (Fig. 2). This conception seems to be quite plausible on the basis of our other data, too, which showed that *T. monococcum* ssp. *boeoticum* is resistant to leaf and stem rust, while *T. urartu* is sensitive to these diseases.

Recently some authors have again proposed the earlier concept that the tetraploids may have originated by autoploidy. JOHNSON (1975), on the basis of electrophoretic patterns of seed proteins, suggested that *T. urartu* might be the source of genome B (Fig. 3). The second

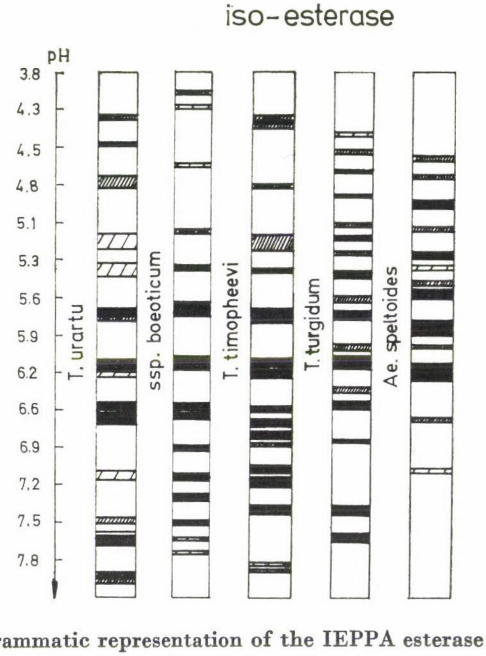


Fig. 1. Diagrammatic representation of the IEPPA esterase zymograms

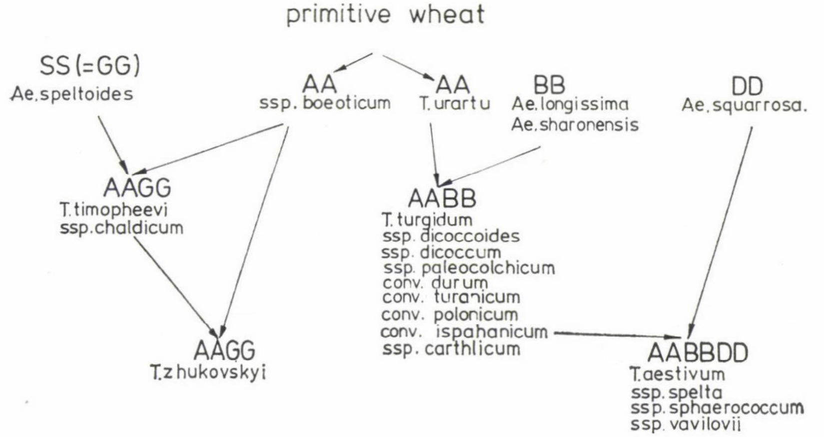


Fig. 2. **Origin of wheat and its relationship according to GUBAREVA *et al.* 1975**

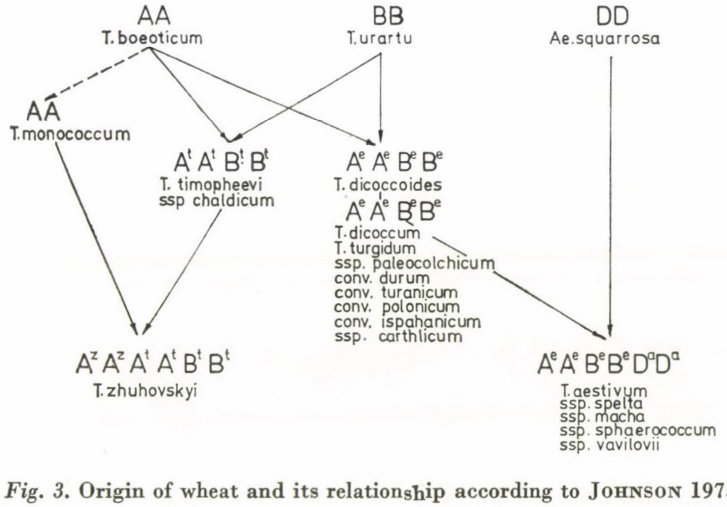


Fig. 3. Origin of wheat and its relationship according to JOHNSON 1975

parental species, according to this hypothesis, is *T. monococcum* ssp. *boeoticum* (genome A). Similar views are shared by DHALIWAL (1976) too. By means of HCST it has been found that the banding of A genome chromosomes is not identical to that of B genome chromosomes. From genome B, properties which *T. urartu* does not possess (e.g. better adaptability, disease resistance, powerful vegetative development, higher chlorophyll content and productivity, etc.) were transferred to emmer wheat by addition. Therefore, it is unlikely that *T. urartu* could be the donor of genome B.

The probability of the autotetraploid origin of tetraploid wheat is diminished further by our observations that the artifically produced autotetraploid *T. monococcum* (AAAA), in spite of its 2n=28 chromosome number, seems morphologically to be closer to *T. monococcum* than to the *T. turgidum* ssp. *dicoccoides*. The autotetraploid *T. monococcum* differs from the starting species only in its slower development, darker green leaves, bigger ears and higher

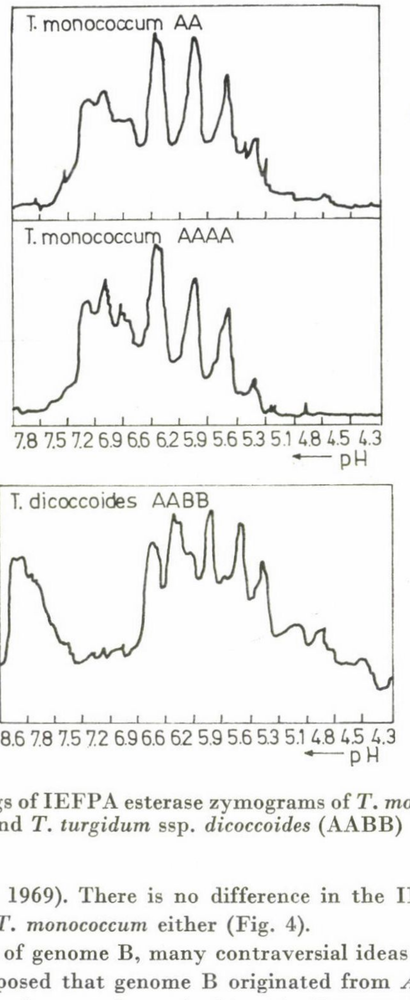


Fig. 4. Densitometer tracings of IEFPA esterase zymograms of *T. monococcum* (AA and AAAA) and *T. turgidum* ssp. *dicoccoides* (AABB)

1000 kernel weight (BELEA 1969). There is no difference in the IEFPA esterase spectra of diploid and autotetraploid *T. monococcum* either (Fig. 4).

Regarding the origin of genome B, many contraversial ideas exist. For example, MACFADDEN—SEARS (1944) proposed that genome B originated from *Agropyron triticeum*. Later SEARS (1956) suggested that it come from *Ae. bicornis*. PATHAK (1940) and later RILEY—CHAPMAN (1958) proposed the most widely accepted theory, according to which *Ae. speltoides* is the donor of genome B.

As is well known, there is experimental evidence against this theory. MAAN—LUCKEN (1971) have shown the different character of the cytoplasmic male sterility of *Ae. speltoides*. JOHNSON's (1975) data on the electrophoretic protein pattern and the banding of chromosomes obtained in our laboratory by HCST, are incompatible with this supposition. Each chromosome of *A. speltoides* has intensive heterochromatic staining, but the chromosomes of *T. turgidum* do not show such intensive banding. The marker chromosome of genome B could not be found in either *Ae. speltoides* (Fig. 5; HADLACZKY—BELEA 1975), nor in *Ae. longissima* (Fig. 6). The comparison of IEFPA esterase spectra of different *Ae. speltoides* lines with those of tetraploid wheats do not support the "speltoides" hypothesis either.

It is possible, of course, that the donor of genome B is a still unknown, or already extinct variety of *Ae. speltoides*. It is also possible that other diploid *Aegilops* species are responsible for the addition of genome B, or perhaps that genome B was synthesized as a result

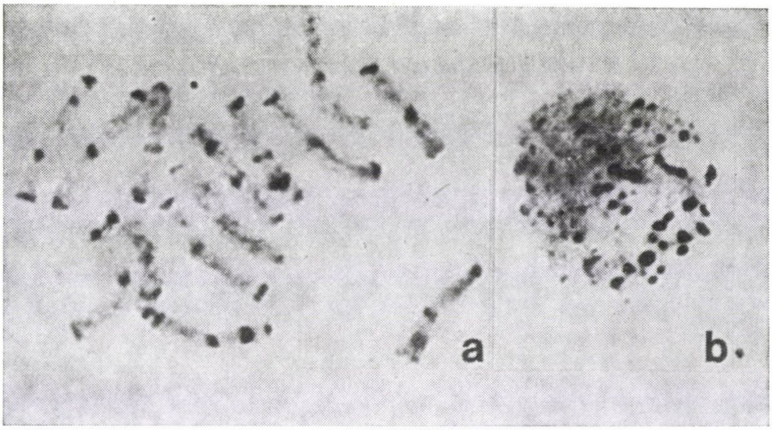


Fig. 5. Giemsa C-banding of *Ae. speltoides. a)* Differential staining patterns of the mitotic chromosomes in metaphase; *b)* heterochromatin in interphase from root-tip meristem

of repeated intercrosses between species with different genomes without a substantial constitutional change in genome A.

As regards *Ae. mutica* as a possible donor of genome B, it was observed that two satellited chromosomes of this species are very similar to the chromosomes 1B and 6B of tetraploid wheat. In the meiosis of F_1 progeny of the cross *Ae. mutica*$\times$*T. turgidum* ssp. *carthlicum* the chromosome conjugation $7^{II} + 7^{I}$ was found with the highest frequency, and $6^{II} + 9^{I}$ with a lower frequency (Table 1). According to these data, genome M of *Ae. mutica* and genome B of tetraploid wheat are homoeologous. Much less homoeology exists between genomes A and M, since in the F_1 hybrids of *Ae. mutica*$\times$*T. monococcum* pairing of chromosomes hardly occurred.

The origin of genome G, which differs from genome B and caused the genetic isolation of *T. timopheevi*, is also unknown. On the basis of the analysis of chromosome pairing (Shands—Kimber 1973), and of the character of cytoplasmic male sterility (Maan—Lucken 1971, Suemoto 1973) it was recently suggested that *Ae. speltoides* could be the donor of genome G. The results of chromosome analysis by HCST failed to support this view (Fig. 7). The chromosome banding of the two species is not identical, although greater similarity has been observed between genome S of *Ae. speltoides* and genome G of *T. timopheevi*, than between genomes S and B of *T. turgidum* (Fig. 8). Finally, the geographic distribution of the tetraploid wheat

Table 1

Chromosome conjugation in the meiosis of Ae. mutica$\times$T. turgidum ssp. carthlicum F_1

Combination	Chromosome number	Cell number	$9^{II} + 3^{I}$	$8^{II} + 5^{I}$	$7^{II} + 7^{I}$	$6^{II} + 9^{I}$	$5^{II} + 11^{I}$	$1^{III} + 5^{II} + 8^{I}$	$2^{III} + 4^{II} + 7^{I}$	$1^{IV} + 5^{II} + 7^{I}$	$1^{IV} + 6^{II} + 5^{I}$
Ae. mutica$\times$*T. turgidum* ssp. *carthlicum*	21	80	1	3	52	15	2	1	2	1	3

species and the recent cytological and biochemical data confirm that *T. timopheevi* originated in some other way.

The hexaploid level also contains two natural groups: *T. zhukovskyi* (AAG) and *T. aestivum* (ABD). The electrophoretic esterase zymograms also support the view that *T. zhukovskyi*

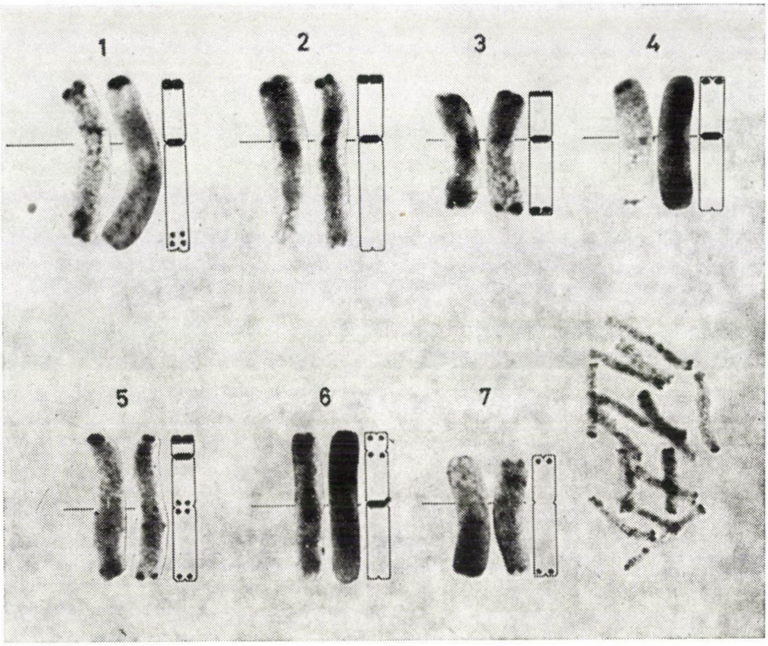


Fig. 6.* Giemsa C-banding of *Ae. longissima

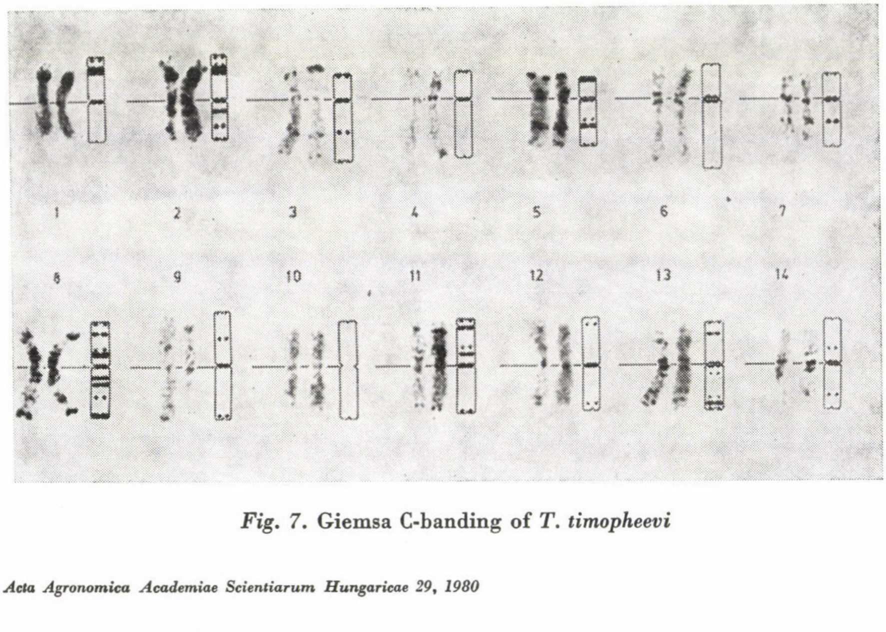


Fig. 7.* Giemsa C-banding of *T. timopheevi

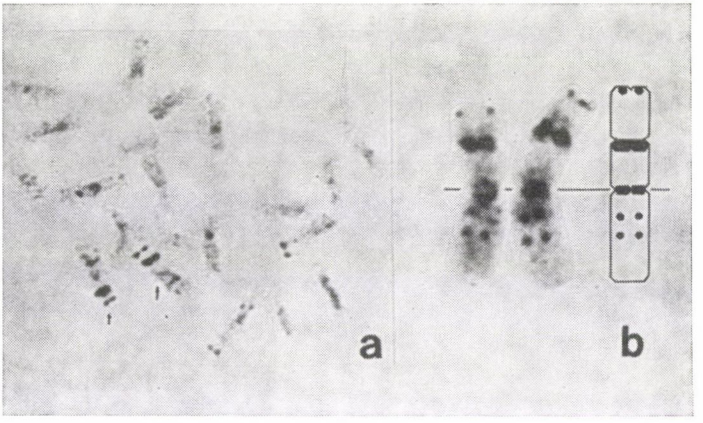


Fig. 8. Giemsa C-banding of *T. turgidum*. *a)* Chromosomes from root-tip meristem. The arrows denote the marker chromosomes of the B genome; *b)* the marker chromosome pair in the B genome

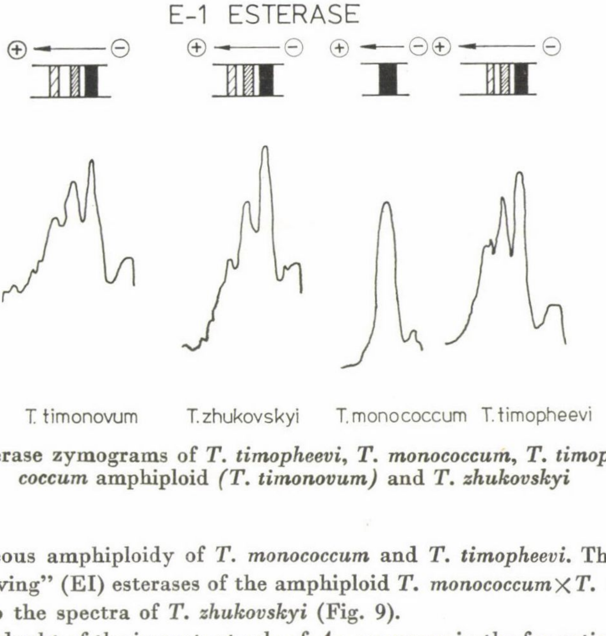


Fig. 9. PAGE esterase zymograms of *T. timopheevi*, *T. monococcum*, *T. timopheevi* × *T. monococcum* amphiploid *(T. timonovum)* and *T. zhukovskyi*

arose by spontaneous amphiploidy of *T. monococcum* and *T. timopheevi*. The spectra of the so-called "fast moving" (EI) esterases of the amphiploid *T. monococcum* × *T. timopheevi* completely conform to the spectra of *T. zhukovskyi* (Fig. 9).

There is no doubt of the important role of *Ae. squarrosa* in the formation of the *T. aestivum* group, since this is the donor of genome D to hexaploid wheat. This view is strongly supported by the data of chromosome pairing (Riley—Chapman 1960). Macfadden—Sears (1944) and Kihara—Lilienfeld (1949) were able to select *T. aestivum* ssp. *spelta* (ABD) from the F_2 progeny of the synthetic amphiploids *T. turgidum* ssp. *dicoccoides* or *T. turgidum* ssp. *dicoccum* × *Ae. squarrosa*.

With HCST all the chromosomes of *Ae. squarrosa* showed a characteristic staining pattern which is identical with that of the chromosomes in genome D (Fig. 10). The charac-

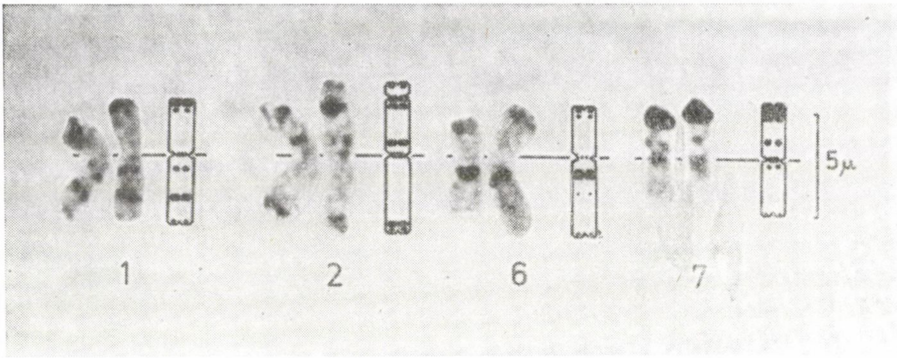


Fig. 10. Giemsa C-banding of *Ae. squarrosa* marker chromosomes

teristic staining patterns of the most striking marker chromosomes are as follows: On the short arm of chromosome 7D (1) there is a prominent terminal band, and under it a tiny heterochromatic spot. On the long arm ($7D^L$) under the centromere, which is poor in heterochromatin, there are two spots. The heterochromatic region of two-thirds of the arm is stained very intensively.

The satellite of the 2D (2) chromosome and the double band at the terminal end of its shorter arm are intensively stained. Above the centromere there is a characteristic spot, and on the $2D^L$ arm a double terminal band.

On the chromosome arm $5D^L$ (6) there is an intensively stained interstitial band. The centromere remain unstained. Chromosome 6D (7) is the richest in heterochromatin and is easily recognisable by its very intensively stained terminal heterochromatin.

According to our data, not only the *Aegilops* species containing genome D (*A. cylindrica* = CD, and Ae. crassa = DM^{cr}), but also other tetraploid *Aegilops* species (e.g. *Ae. triuncialis* = CC^u, *Ae. ovata* = C^uM^o, *Ae. biuncialis* = C^uM, *Ae. triaristata* = C^uM^t) are substantially more readily crossed with hexaploid wheat (*T. aestivum* ssp. *aestivum*, ssp. *spelta*, ssp. *macha*, ssp. *sphaerococcum*, etc.) than with tetraploids (*T. turgidum* ssp. *turgidum*, ssp. *dicoccum*,sssp. *carthlicum*, conv. *durum*, etc.) (Table 2). The chromosome pairing between the C and D genomes of these *Aegilops* species and genome D of bexaploid wheat was also much better (Table 3). For example, in the meiosis of the F_1 progeny of the *Ae. cylindrica*×*T. aestivum* cross, the chromosome conjugations $7^{III} + 21^I, 10^{II} + 13^I$ were observed most frequently. The picture in the meiosis of F_1 hybrids of the crosses *Ae. cylindrica*×*T. aestivum* ssp. *vavilovi* and *Ae. biuncialis*×*T. aestivum* was similar. The occurrence of trivalents and quadrivalents was observed at quite a high frequency, mainly in the cross *Ae. triuncialis*×*T. aestivum.*

Gorgidze (1971) studied the possible role of *Ae. ovata* in the evolution of hexaploid wheat by analysing the cross *T. turgidum* ssp. *dicoccoides*×*Ae. ovata*. For the same purpose the authors have produced amphiploid *Ae. ovata*×*T. turgidum* ssp. *carthlicum* ($AABBC^uC^uM^oM^o$). In the F_2—F_3 progeny no segregants similar to cultivated wheat have been observed. The data obtained by HCST also failed to support the homology of the whole genome of the tetraploid *Aegilops* species (*Ae. biuncialis*, *Ae. ovata*, etc.) with genome D of hexaploid wheat.

For the time being the origin of *T. aestivum*, one of the most important crops for humanity, is not properly known. Percival's (1921) so-called "*Aegilops* hypothesis" was the most widely accepted for a long time. According to this hypothesis, *T. aestivum* is a reduced amphiploid of *T. turgidum* ssp. *dicoccum*×*Ae. cylindrica;* but later, on the basis of the accumulated experimental data, this hypothesis proved to be unacceptable.

Table 2

Crossing data of different tetraploid Aegilops species to the tetraploid and hexaploid wheats

Combination	Number of flowers crossed	Seed setting %	Germination %
Ae. cylindrica × tetraploid wheat	1303	5.7	51.2
reciprocal	378	2.9	36.4
Ae. crassa × tetraploid wheat	464	5.4	42.9
reciprocal	40	0.0	0.0
Ae. ovata × tetraploid wheat	1282	9.6	54.8
reciprocal	712	0.0	0.0
Ae. biuncialis × tetraploid wheat	40	7.5	33.3
Ae. triuncialis × tetraploid wheat	944	4.4	44.2
Ae. triaristata × tetraploid wheat	168	1.7	0.0
4x *Aegilops* × 4x *Triticum*	4201	5.7	37.7
4x *Triticum* × 4x *Aegilops*	1130	0.9	12.1
Ae. cylindrica × hexaploid wheat	2788	23.3	59.2
Ae. crassa × hexaploid wheat	128	25.7	66.6
Ae. ovata × hexaploid wheat	2429	11.9	29.9
Ae. biuncialis × hexaploid wheat	340	9.2	36.8
Ae. triuncialis × hexaploid wheat	1627	6.2	27.7
Ae. ventricosa × hexaploid wheat	48	14.5	71.4
4x *Aegilops* × 6x *Triticum*	7360	15.1	48.6

SEARS (1956b) suggested three possibilities for the origin of *T. aestivum: a)* by amphiploidy from *T. turgidum* ssp. *carthlicum* × *Ae. squarrosa, b)* through segregation from *T. aestivum* ssp. *spelta* × *T. turgidum* ssp. *carthlicum*, and *c)* as a result of a mutation in *T. aestivum* ssp. *spelta*. The authors suggest that all three ways of evolution might be possible. Moreover, other evolutionary processes could also have played a role in the formation of common wheat. In our experiments, the F_2 progeny of the cross *T. aestivum* ssp. *spelta* × *T. turgidum* ssp. *carthlicum* contained not only squarehead and compactoid sterile segregants, but also plants of the constant *T. aestivum* type. They were identical with cultivated wheat in every respect (morphological, cytological, genetical, etc. characteristics), moreover, their seed setting was the same as is usually observed in crosses between varieties, and the progeny was entirely fertile (BELEA 1971). MAC KEY (1975) also considers the possibility that *T. aestivum* arose from *T. aestivum* ssp. *spelta*. The two species differ only in the presence of factor q, which is located on the 5A chromosome and is responsible for the naked seed.

But since at present *T. aestivum* ssp. *spelta* is considered to be younger than *T. aestivum*, it is possible that it enriched the variability of common wheat at a later time. Naturally, *T. aestivum* ssp. *spelta* could also have arisen by mutation from *T. aestivum* (SWAMINATHAN 1963). Depending on the weather conditions, the authors have obtained speltoid plants in a field population of *T. aestivum*, as have others (e.g. LELLEY—RAJHÁTHY 1955).

It is very probable that the extraordinarily high adaptability and great variability of hexaploid wheat, mainly of *T. aestivum*, is due to its polyphyletic origin, to genome D of *Ae. squarrosa*, and to the conscious activity of man. Under totally new environmental and ecological conditions, only the individuals with the greatest vitality survived, while all the other plants of a given population perished. The diploid species adapted themselves to a definite environment, but the alloploids, which contain genomes from species with different ecological demands, had acquired higher adaptability.

Table 3

Chromosome pairing in the meiosis of tetraploid Aegilops × hexaploid Triticum F_1

Combination	Number of cells examined	Chromosome number	As a percentage of total cell number	$15^{II} + 5^{I}$	$13^{II} + 9^{I}$	$12^{II} + 12^{I}$	$11^{II} + 13^{I}$	$10^{II} + 15^{I}$	$9^{II} + 17^{I}$	$8^{II} + 19^{I}$	$7^{II} + 21^{I}$	$6^{II} + 25^{I}$	$6^{II} + 23^{I}$	$5^{II} + 25^{I}$	trivalents	quadrivalents
Ae. cylind. × conv. *vav.*	31	35	100	3	2	7	8				10				1	
Ae. cylind. × *T. aest.*	97	35	83.5	2	2		13	15	3	4	14				25	6
Ae. cylind. × *T. aest.*	97	36	7.2			2									4	1
Ae. cylind. × *T. aest.*	97	37	7.2									6			1	
Ae. biunc. × *T. aest.*	83	35	92.8					3	6		15		13	9	28	3
Ae. biunc. × *T. aest.*	83	36	6.0			3									2	
Ae. biunc. × *T. aest.*	83	37	1.2												1	
Ae. triunc. × *T. aest.*	171	35	84.8	4	5		2	3	4	2	6		2	2	48	69
Ae. triunc. × *T. aest.*	171	36	7.6			1									4	8
Ae. triunc. × *T. aest.*	171	37	2.9									4			1	
Ae. triunc. × *T. aest.*	171	34	4.7													8

As is seen from the above discussion, the origin of different wheat species, and mainly that of *T. aestivum*, is not satisfactorily clear. In spite of the tremendous quantity of experimental data, which seem to have solved many important questions, there is still a lot of work to be done in clarifying the natural systematics, origin and relationships of the wheat species.

*

Prepared at the Institute of Genetics, Biological Research Centre of the Hungarian Academy of Sciences, Szeged.

A. BELEA, O. FEJÉR

References

BELEA, A. (1969): Genetic study on *Triticum monococcum* L. reduced from tetraploid to diploid. Acta Agron. Hung., **18**, 254–258.

BELEA, A. (1971): Are there other possibilities for the origin of *T. spelta* or *T. aestivum?* Acta Agron. Hung., **20**, 227–229.

DHALIWAL, H. S. (1976): Fertility and morphology of the synthetic amphiploids and the origin of tetraploid wheats. Cer. Res. Com., **4**, 411–417.

GIORGI, B.—BOZZINI, A. (1969): Caryotype analysis in *Triticum*. III. Analysis of the presumed diploid progenitors of polyploid wheats. Caryologia, **22**, 279–288.

GORGIDZE, A. D. (1971): The synthesis of hexaploid wheats. Soobshch Akad. Nauk. Gruz. SSR., **63**, 669–672.

GUBAREVA, N. K.—GAVRILJUK, J. P.—PENEVA, T. I.—KONAREV, A. V. (1975): Wheat genome origination on the data of biochemical and serological studies of seed proteins. All-Union N. I. Vavilov Inst. Pl. Industry, Leningrad.

HADLACZKY, GY.—BELEA, A. (1975): C-banding in wheat evolutionary cytogenetics. Plant Sci. Letters, **4**, 85–88.

JAASKA, V. (1974): The origin of tetraploid wheats on the basis of electrophoretic studies of enzymes. Acad. Sci. Estonian SSR. Biologia, 3.

JOHNSON, B. L. (1975): Identification of the apparent B-genome donor of wheat. Proc. Nat. Acad. Sci. USA, **69**, 1398–1402.

KIHARA, H.—LILIENFELD, F. (1949): A new synthesized 6×-wheat. Proc. 8th Intern. Congr. Genet. Stockholm, 1948. Hereditas Suppl., **1**, 307–319.

KONAREV, A. V. (1975): Differentiation of the first genomes of polyploid wheats based on data from immunochemical analysis of ethanol fraction of grain proteins. Bull. All-Union N. I. Vavilov Inst. Pl. Industry, Leningrad, **47**, 8–11.

KONAREV, A. V.—PENEVA, T. I. (1975): Gliadins of Aegilopses of the Sitopsis (Jaub. et Spach) Zhuk. section and the structure of the S (B) genome. Agric. Biol. USSR, **10**, 211–219.

LELLEY, J.—RAJHÁTHY, T. (1955): A búza és nemesítése (Wheat and its breeding). Akadémiai Kiadó, Budapest.

MAAN, S. S.—LUCKEN, K. A. (1971): Nucleo-cytoplasmic interaction between cytoplasm of *Aegilops* and genomes of *Triticum* species. J. Hered., **62**, 149–152.

MACFADDEN, E. S.—SEARS, E. R. (1944): The artificial synthesis of *Triticum spelta*. Res. Genet. Soc. Amer., **13**, 26–27.

MAC KEY, J. (1975): The boundaries and subdivision of the genus *Triticum*. 12th Intern. Bot. Congr., Leningrad.

PATHAK, G. N. (1940): Studies in the cytology of cereals. J. Genet., **39**, 437–467.

PERCIVAL, J. (1921): The wheat plant. A monograph. Duckworth. Co. London, 473.

RILEY, R.—CHAPMAN, V. (1958): Evidence on the origin of the B genome of wheat. J. Hered., **49**, 91–98.

RILEY, R.—CHAPMAN, V. (1960): Genetic control of the cytologically diploid behaviour of hexaploid wheat. Nature, **182**, 713–715.

SEARS, E. R. (1956): The B genome of *Triticum*. Wheat Inform. Serv. Kyoto, **4**, 8–10.

SHANDS, H.—KIMBER, G. (1973): Reallocation of the genomes of *Triticum timopheevi* Zhuk. Proc. 4th Intern. Wheat Genet. Symp. Columbia, Missouri, 101–108.

SUEMOTO, H. (1973): The origin of the cytoplasm of tetraploid wheats. Proc. 4th Intern. Wheat Genet. Symp. Columbia, Missouri, 109–113.

SWAMINATHAN, M. S. (1963): Mutational analysis of the hexaploid *Triticum* complex. Proc. 2nd Intern. Wheat Genet. Symp., Lund.

RESULTS AND OBJECTIVES OF WINTER WHEAT BREEDING AT MARTONVÁSÁR

The Martonvásár wheat breeding group, which was set up in the middle of the fifties, is working in a period when wheat production is developing at a rate never before experienced, as illustrated in Table 1. Over the past fifteen years the Hungarian wheat yields have doubled, or even tripled in good farms. As a consequence of the rapid development a different type of wheat is called for in each successive decade. Varieties soon become out-of-date; today the average lifetime of a wheat variety is 5—6 years.

Since 1971 the results of wheat breeding at Martonvásár have appeared continuously. The first successful crossings were performed at the beginning of the sixties, and in 1969 an application for state certification was made for the first experimentals resulting from these crosses. State certification has so far been granted to a total of 8 Martonvásár wheats, and a further 9 experimentals are now being tested in national variety trials.

Table 1

Yield average of winter wheat in Hungary

Year	Yield, q/ha
1961–65	18.6
1966–70	24.8
1971–75	33.2
1976	38.8
1977	40.5
1978	42.8

The wheat breeding is aimed at producing high yielding, winter hardy varieties of excellent quality, resistant to drought, powdery mildew and stem and leaf rust, which assimilate economically and are suitable for mechanical harvesting (Rajki 1960, Balla 1968, Szunics 1973, Koltay—Balla (1975). The objectives are modified and modernized from time to time according to the trend of development in wheat production (Balla 1978). The 30—35 q/ha yield initially set as a breeding objective has thus become 80—100 q/ha. Great efforts are made to shorten the straw, that is, to produce semidwarf varieties, to increase the amount of protein and improve the amino acid composition, to achieve adaptability to different ecological conditions and obtain positive responses to various methods of production technology and fertilization, and to increase tolerance to monoculture and resistance to diseases (*Fusarium* sp., *Cercosporella* and *Ophiobolus*, *Puccinia striiformis*, viruses).

Since 1974 the phytotron technique has successfully been used in wheat breeding; three generations are raised every year in this way for the purpose of crossing. In general, complicated hybrids are produced using the method developed at Martonvásár, and the hybrid material is only tested in the field when all the desirable agronomical characters have been "built in" to the population. Selection is carried out in the F_2 and F_3 generation. After four years of testing the best lines are tested first in local trials, then in national variety trials, and at the same time the repeated selection of the populations is begun. During the four years of testing the winter hardiness of the lines is determined in the phytotron, and their quality, disease resistance and other agronomical properties are tested under field conditions.

At present two teams are engaged in wheat breeding at the Martonvásár institute, the fodder wheat breeding group, which produced the variety Martonvásár 8 (Szilágyi 1978), and the wheat breeding group which has produced all the other Martonvásár varieties and the experimentals currently being tested in national variety trials.

Productivity. As a result of the wheat breeding carried out at Martonvásár so far, the first three varieties (Martonvásár 1, Martonvásár 2 and Martonvásár 3) reached the level of Bezostaya 1, the best variety at the time they were qualified (Table 2). Of these varieties Martonvásár 1, which was given special recognition in 1976, is commercially produced at present. State certification for Martonvásár 2 and Martonvásár 3 was withdrawn in 1976 when the new experimentals which appeared proved to be better.

The subsequent varieties, Martonvásár 4, Martonvásár 5 and Martonvásár 6, were even better than the earlier ones. Martonvásár 4 in particular was a great success; in 1977 it became the standard of the early group and was given special recognition in 1978. The original forms of Martonvásár 5 and 6 were not completely uniform, so improved forms have been produced by selection, and these are now being propagated and tested. These varieties have considerably shorter stems, are more resistant to lodging and give a more reliable yield, while their other properties are similar to those of the original population.

The Martonvásár wheat varieties have also done well in the national variety trials. The 1978 results are shown in Table 3.

The Martonvásár varieties were tested in the midseason maturity group where Jubileinaya 50 is the standard. The first seven places in the trial were taken by Martonvásár varieties or experimentals. Of these, Martonvásár 8, Mv 22-77, Mv 06-77, Mv 07-77, Mv 06-75 and Martonvásár 7 significantly surpassed the standard variety Jubileinaya 50. The trial also revealed that the variety Martonvásár 4 is significantly better (this year 8.7% better) than Jubileinaya 50 as regards productivity. These yields mean that the best Martonvásár varieties and experimentals tested in the midseason maturity group reached or even surpassed the level of the highest yielding early varieties; at the same time they are winter hardy, of good quality, and more resistant to lodging than the early varieties.

Table 2

Productivity of Martonvásár wheats
(Martonvásár, 1972–1978)

Variety	1972	1973	1974	1975	1976	1977	1978	Average	%
	yield, q/ha								
Bezostaya 1	41.8	63.3	61.8	40.4	69.1	57.5	52.5	55.2	100.0
Martonvásár 1	44.3	68.2	68.1	53.2	74.6	55.3	55.9	59.9	108.5
Martonvásár 2	47.5	66.7	66.1	43.9	61.9	56.8	47.1	55.7	100.9
Martonvásár 3	46.9	63.4	61.3	45.4	62.6	58.4	48.8	55.3	100.2
Martonvásár 4	53.7	70.3	58.2	53.8	82.9	62.7	61.2	63.3	114.7
Martonvásár 5	50.1	70.5	65.5	59.0	78.9	64.4	56.4	63.5	115.0
Martonvásár 6	69.9	69.3	72.3	57.8	77.1	58.7	62.2	66.7	120.8
Martonvásár 7	—	67.5	79.4	51.7	75.3	62.6	65.7	67.0	121.4
$LSD_{5\%}$	3.1	4.0	5.4	5.9	4.0	5.2	6.2		

Number of replications: 6.
Plot size: 20 m^2.

Table 3

Yields of midseason Martonvásár wheat varieties and experimentals in the national variety trials
(1978 data of the National Agricultural Variety Testing Institute)

Variety	Yield	
	q/ha	%
Mv 103 experimental	64.3	113.8
Mv 22-77 experimental	62.1	109.9
Mv 06-77 experimental	61.7	109.2
Martonvásár 4	61.4	108.7
Mv 07-77 experimental	60.6	107.3
Mv 06-75 experimental	59.7	105.7
Mv 11-75 experimental	59.5	105.3
GK 11-77 experimental	58.5	103.5
Mv 18-77 experimental	57.6	101.9
Rivoli (French)	57.5	101.8
Sadovo (Bulgarian)	57.5	101.8
Levent (Bulgarian)	56.5	100.0
Jubileinaya 50 (Soviet)	56.5	100.0
Mv 27-74 experimental	55.2	97.7
Ludogorka (Bulgarian)	55.2	97.7
Martonvásár 5	55.0	97.3
Martonvásár 1	54.7	96.8
Martonvásár 6	54.5	96.5
Partizanka (Yugoslav)	53.9	95.4
Bezostaya 1 (Soviet)	52.4	92.7
Wattines (French)	51.6	91.3
Average	57.4	
$LSD_{5\%}$	2.8	
Number of stations	15	

Note: In 1978 Mv 11-75 was certified under the name Martonvásár 7, and Mv 103 as Martonvásár 8.

The yield results achieved by experimentals bred at Martonvásár in recent years are contained in Table 4. The experimentals submitted for qualification in 1977 and 1978, respectively, form two separate groups; the former were tested for three and the latter for two years in replicated experiments at Martonvásár and at six experimental stations of the National Agricultural Variety Testing Institute.

The new experimentals are high yielding and give a good response to fertilization. They look as though they may be capable of producing 100 q/ha.

Mechanical harvesting. Lodging represents one of the greatest problems of wheat production in Hungary. The aim to produce short-strawed semidwarf varieties was set at the very beginning, but it has only been attained gradually. The height of the first experimentals was similar to that of Bezostaya 1 (90—95 cm), but owing to their better fertilizer responses increasing rates of fertilization have resulted in them reaching or even exceeding 100 cm. However, the improved Martonvásár 6, Martonvásár 7 and Martonvásár 8 varieties show a gradual change for the better, and up to a yield level of 60-65 q they do not lodge.

Still more resistant to lodging are the experimentals submitted for qualification in 1977 and 1978; in the former group the straw is shorter by 10—15 cm and in the latter by 30—35 cm compared to that of Bezostaya 1 (Table 5). The latter did not lodge even in the stormy year of 1978. According to our present knowledge 75—80 cm can be considered the optimum height for wheat plants. Straw shorter than this is only justified under irrigated conditions, if at all. The aim when shortening the straw is to find the optimum length that renders mechanical harvesting possible, does not result in a reduction of individual productivity and adaptability, but is tall and dense enough to suppress the weeds. Although weeds can be chemically controlled, herbicides distributed in April before shooting do not give protection from summer weeds. The latter must be suppressed by the crop.

Table 4

Productivity of Martonvásár experimentals
(Martonvásár, 1976—1978)

Designation	Yield, q/ha				
	1976	1977	1978	Average	%
		1977 experimentals			
Bezostaya 1	76.6	60.3	52.5	63.1	100.0
Mv 06-77	83.7	75.0	75.0	77.9	123.4
Mv 07-77	84.0	74.9	67.7	75.5	119.6
Mv 18-77	77.7	72.1	64.7	71.5	113.3
Mv 22-77	75.1	76.8	70.1	74.0	117.3
Mv 23-77	72.2	79.0	71.6	74.3	117.7
$LSD_{5\%}$	3.6	4.2	6.2		
		1978 experimentals			
Bezostaya 1	—	65.5	67.3	66.4	100.0
Mv 02-78	—	78.0	78.4	78.2	117.8
Mv 03-78	—	77.8	77.6	77.7	117.0
Mv 07-78	—	79.5	76.9	78.2	117.8
Mv 1-08-78	—	94.0	82.3	88.1	132.7
Mv 2-24-78	—	81.7	78.5	80.1	120.6
$LSD_{5\%}$	—	7.2	6.3		

Number of replications: 5.
Plot size: 20 m^2.

Quality. The first Martonvásár wheat varieties are well known for their excellent quality. The milling and baking industries still regret the withdrawal of Martonvásár 2 and Martonvásár 3, and use the variety Martonvásár 4 to improve the quality of the flour. The relevant data are presented in Table 5.

Table 5

Plant height and quality in Martonvásár wheat varieties and experimentals
(Martonvásár, 1976–1978)

Designation	Plant height, cm	Farinographic value	Qualification	Loaf volume, cm^3
Bezostaya 1	105	95.3	A_1	437
Martonvásár 1	113	84.7	A_2	429
Martonvásár 4	109	100.0	A_1	489
Martonvásár 5	112	95.8	A_1	519
Martonvásár 6	102	76.8	A_2	433
Martonvásár 7	103	92.0	A_1	451
Martonvásár 8	101	68.6	B_1	382
1977 experimentals				
Mv 06-77	91	54.6	B_2	317
Mv 07-77	94	53.7	B_2	405
Mv 18-77	89	72.4	A_2	409
Mv 22-77	95	81.7	A_2	491
Mv 23-77	90	89.6	A_1	529
1978 experimentals				
Mv 02-78	83	88.6	A_1	467
Mv 03-78	76	77.4	A_2	482
Mv 07-78	73	82.8	A_2	409
Mv 1-08-78	71	75.6	A_2	367
Mv 2-24-78	86	92.4	A_1	445

The variety Martonvásár 4 is noted for its high farinographic value and A_1 quality. Its loaf volume also exceeds that of Bezostaya 1. Martonvásár 5 is similar to Bezostaya 1 in farinographic value, but has a considerably better loaf volume. The flour obtained from these varieties is highly suitable for mechanical processing. The gluten is strong and not sticky and the dough keeps its form well, with the consequence that the shape of the bread is also favourable.

Although Martonvásár 6 and Martonvásár 8 are somewhat inferior in quality to the varieties described above, they are still suitable for milling and baking purposes without improvement.

Table 6

Stem and leaf rust infection in Martonvásár wheat varieties and experimentals in inoculation tests
(Martonvásár, 1976–1978)

Designation	Stem rust			Leaf rust		
	1976	1977	1978	1976	1977	1978
Bezostaya 1	3	3; 2	3; 2	2	3; 4	2
Martonvásár 1	4	4	4	2	4	3
Martonvásár 4	3	3; 2	3; 4	3	4; 3	4; 3; 2
Martonvásár 5	3; 4	3; 4	4; 3	3	4; 3	3; 2; 4
Martonvásár 6	4; 3	4; 3	4; 3	3	4; 3	3; 2
Martonvásár 7	3	3; 2	4; 3	3	4; 3	3; 4
Martonvásár 8	3; 2	—	3	4; 3	—	4; 3
1977 experimentals						
Mv 06-77	3; 4	4; 3	3	1; 2; 3	2; 3	1
Mv 07-77	1; 2	1; 2; 3	2; 1; 3	3; 2; 4	2; 3; 4	3; 4
Mv 18-77	1	1; 3	1	2; 1	2; 3	2; 3
Mv 22-77	3	3	4	3; 4; 2	4	4; 3
Mv 23-77	3	3; 4	4	4; 3; 2	4	3; 4
1978 experimentals						
Mv 02-78	—	1	1	—	2; 1	1
Mv 03-78	—	1; 3	1	—	1; 2; 3	1
Mv 07-78	—	1	1	—	2; 1	2; 1
Mv 1-08-78	—	1	1	—	1; 2	1
Mv 2-24-78	—	1	1	—	2; 3	1

Note: 0 = highly resistant; 1 = resistant; 2 = medium resistant; 3 = medium susceptible; 4 = susceptible. If more than one figure is given (e.g. 3; 2) the first figure is more characteristic.

The farinographic qualification is B_2 for two, A_2 for two, and A_1 for one of the 1977 experimentals. Of the 1978 experimentals two have A_1 and three A_2 quality. They also have satisfactory loaf volumes which are hardly, if at all, inferior to that of Bezostaya 1. Two experimentals, however, Mv 06-77 and Mv 1-08-78, have poorer loaf volumes than Bezostaya 1, while that of Mv 23-77 is better, according to the investigations made so far (Table 5).

The improvement of productivity in the new experimentals has involved a certain deterioration in quality. The highest yielding Mv 06-77 and Mv 1-08-78 seem to be of poorer quality, as is seen most clearly in their loaf volumes; nevertheless the farinographic value of these lines is medium or good. The rest of the experimentals are equal to Bezostaya 1 as regards quality, so they satisfy the requirements.

Productivity and quality in some experimentals seem to verify the existence of a negative correlation between these two properties, though this is not as strong as that found earlier (LELLEY—RAJHÁTHY 1955).

Disease resistance. In Hungary stem rust is the most important wheat disease; its appearance generally results in a yield reduction. Although leaf rust is also a frequent disease in Hungary it usually causes less damage. The variety Bezostaya 1 shows sufficient field resistance to both diseases and is only seriously infected in inoculation tests (MANNINGER 1962). The initial aim of the wheat breeding at Martonvásár was to attain a disease resistance level at least equal to that of Bezostaya 1, that is, not to produce any experimentals or varieties with susceptibility considerably higher than that of Bezostaya 1. The recently certified Martonvásár winter wheat varieties meet this requirement; only the resistance of Martonvásár 1 and Martonvásár 6 to stem rust and that of Martonvásár 8 to leaf rust have proved inferior to that of Bezostaya 1 (Table 6).

Resistance to stem and leaf rust in the new experimentals is, however, at least as high, if not higher, than in Bezostaya 1. Particularly noteworthy are the 1978 experimentals, which are hardly infected by these two diseases and even show resistance to powdery mildew. By introducing these experimentals into commercial production it should be possible to practically prevent the danger of infection by stem and leaf rust (Table 6).

To develop resistance to powdery mildew is one of the most difficult breeding tasks, but it can no longer be postponed since this pathogen is beginning to assume serious proportions. Although all the registered Martonvásár wheat varieties are one or two degrees better than the standard variety Bezostaya 1, they are still not resistant. The 1977 experimentals, however, are two to three degrees more resistant than the earlier ones; in practice they are less than medium susceptible. The 1978 experimentals are still better; they are hardly infected at all by powdery mildew (Table 7).

The place of Martonvásár wheats in production. The Martonvásár wheat varieties certified so far are gradually gaining ground. While three years ago the area they occupied was insignificant, Martonvásár wheats are now harvested on more than 25% of the sowing area. Great interest is shown in Martonvásár 7 and Martonvásár 8, the two varieties certified in 1978. The experimentals submitted in 1977 and 1978 are expected to be registered in 1979 and 1980.

The older varieties can be successfully grown without lodging at a yield level of 35—50 q/ha, i.e. on most parts of the arable area of Hungary. The recently certified Martonvásár varieties are likely to become the wheats of the 50—65 q/ha areas, while the latest experimentals will be capable of producing 70—90 or even 100 q/ha without the danger of lodging or infection by pathogens.

Further objectives. As wheat production develops breeders are faced with ever greater tasks. The higher level of production also involves special problems which can primarily be solved through breeding.

The improvement of productivity and its combination with good fertilizer response will continue to be the most important objectives of wheat breeding. New varieties must be produced to make high rates of fertilization economical and to reach yields exceeding 100 q/ha. For this purpose a new type of variety is needed which is more responsive to fertilization, assimilates more efficiently and accumulates the larger part of the assimilates in the grain, thus having a favourable grain-straw ratio. At higher nutrient levels the present varieties produce too much straw. The aim is to approach a 1 : 1 ratio.

Further possibilities of attaining larger grain yields seem to be offered by an increase in individual productivity and the improvement of tolerance to stand density. It is well known that productivity can be increased by the improvement of three components: number of spikes/m^2, number of grains/spike and thousand-grain-weight. It has lately been proved that

Table 7

Powdery mildew infection in Martonvásár wheat varieties and experimentals in field trials
(Martonvásár, 1976–1978)

Designation	Powdery mildew infection		
	1976	1977	1978
Bezostaya 1	6	6	8
Martonvásár 1	6	5	6
Martonvásár 4	4	6	7
Martonvásár 5	4	4	5
Martonvásár 6	5	5	8
Martonvásár 7	5	5	7
Martonvásár 8	4	4	4
1977 experimentals			
Mv 06-77	1	3	2
Mv 07-77	5	7	6
Mv 18-77	4	3	3
Mv 22-77	3	4	5
Mv 23-77	3	5	4
1978 experimentals			
Mv 02-78	0	1	1
Mv 03-78	0	2	1
Mv 07-78	0	1	0
Mv 1-08-78	0	0	0
Mv 2-24-78	0	1	2

Note: 0 = resistant; 9 = susceptible.

high yielding varieties must possess high individual productivity. This can best be attained with big spikes and large grain weight per spike. Of all the yield components, attempts are primarily being made to increase the number of grains, then the number of spikes/m^2, while keeping the thousand-grain-weight at the level of the best current varieties, or if possible slightly improving it.

The resistance of the varieties to lodging must be maintained at the level of the most recent experimentals, though a further step is to improve the quality of these short, strong-stalked varieties and to establish a constant "A" quality, at the same time retaining the present level of resistance to powdery mildew, stem and leaf rust.

These tasks require a great deal of time and effort. It is a great help that a wide range of complex crossing can be carried out in the phytotron, for which a new breeding strategy has been elaborated. The essence of this is that by setting up a well-thought-out crossing programme on the basis of the results obtained so far all over the world, and by achieving the highest possible level of mechanization and the precise execution of the field trials, new varieties can be produced which will combine all the favourable features and will be suitable to replace the foreign varieties still in commercial production (Balla 1978).

*

Prepared at the Agricultural Research Institute of the Hungarian Academy of Sciences, Martonvásár.

L. Balla, L. Szunics, M. Manninger
Zs. Pollhamer, Gy. Szilágyi

References

Balla, L. (1968): A búza termőképesség re való nemesítésének egyes kérdései (Some questions of breeding wheat for productivity). Candidate's dissertation, Martonvásár, 142.

Balla, L. (1978): Wheat breeding strategy in the Martonvásár Phytotron. Proc. of the Conference on Cytogenetics and Crop Improvement. Hindu University, Varanasi, India.

Koltay, Á.—Balla, L. (1975): Búzatermesztés és -nemesítés (Wheat production and breeding). Mezőgazdasági Kiadó, Budapest, 1—253.

Lelley, J.—Rajháthy, T. (1955): A búza és nemesítése (Wheat and its breeding). Akadémiai Kiadó, Budapest, 1—365.

Manninger, M. (1962): Studies on the resistance of wheat varieties to stem rust of cereals (*Puccinia graminis tritici* Erikss. et Henn.) and leaf rust of wheat (*Puccinia triticina* Erikss.) in Martonvásár 1960—1961. Proc. Symp. Genetics and Wheat Breeding, Martonvásár, 313—328.

Rajki, S. (1960): Közönséges búzafajták tenyészideje és megváltoztatásának egyes módjai (Vegetation periods of common wheat varieties and some ways of changing them). Növénytermelés, **9**, 113—130.

Szilágyi, Gy. (1978): Practical value of radiation induced wheat mutations in Hungary. Mutation Breeding Newsletter, Vienna, **12**, 1—4.

Szunics, L. (1973): Krasznodári búzafajták Magyarországon (Krasnodar wheat varieties in Hungary). Növénytermelés, **22**, 373—379.

HERBARIUM DATA FROM THE COLLECTIONS OF THE KISMARTON PARK AND GREENHOUSES IN 1844—1845

The Kismarton (Eisenstadt) park and greenhouses contained the most noteworthy botanical collection in Hungary at the beginning of the last century. Until recently, however, the only information about its size have been the numerical data processed by Rapaics (1940). Thus it was known that the large greenhouses contained 60.000 plants; plants from the tropics, Manhattan island and Cape Colony were grown in separate sections, and there was an orange-house and a separate house for succulents. According to verbal information received from Szaniszló Priszter, lists of the plants in the Esterházy family's park and greenhouses at Kismarton have recently come to light, with the help of which it will be possible, to some extent, to reconstruct the plant-life of the park, the composition of which was previously almost entirely unknown.

The Botanical Department of the Teachers' Training College, Pécs, was presented with the herbarium of the former college of Pannonhalma Abbey. This was handed over in several parts, the last in 1977. The herbarium consists of some 40,000 sheets, half of which is known as the basic collection and the other half as the Piers collection. The catalogue and the card-index of the basic collection were completed in 1977. During this work the Kismarton material from 1844 and 1845, a collection by Flóris Ferenc Rómer (1815—1889), was found. During

Fig. 1. Flóris Rómer

the period in question Rómer was the natural history teacher at the Győr Seminary and collected a herbarium of considerable size. (Rómer is also known as the founder of the history of art in Hungary.)

On the herbarium sheets mentioned above the habitat (Kismarton), the year, and in some cases, as a more precise localization, the Esterházy garden or even the greenhouse are given. The sheets do not always show the collector's name. This deficiency was overcome by the place and date of collection and by identifying the hand writing. The name of the author is missing from the plant names, but these are given here. The plants are in good condition; originally they were not fixed to the sheets.

In the meantime the catalogue of the herbarium collected by Dr. József Jemelka, which was also kept at Pannonhalma and was unknown up till now, has also been completed. This collection was compiled between 1843 and 1847, and mostly contains plants from Sopron, though the data from Buda and Pest are also interesting. Six of the sheets should be included in this description: two greenhouse orchids, two violet species and the wild garlic are indicated as originating from the Esterházy park (1844, 1847), while the Viola mirabilis was obtained from Kismarton.

The plants are listed in families in taxonomic order. Within the families alphabetical order is used. The out-of-date nomenclature has been supplemented with the currently accepted names.

The Kismarton plants are:

Polypodiaceae

Adiantum Capillus-Veneris L.
— *reniforme* L.

Blechnum occidentale L.
Platycerium alcicorne (Willem.) Desv.
Polypodium aureum L. = *Phlebodium a.* (L.) Smith
— *fragile* L. = *Cystopteris f.* (L.) Bernh.

Cupressaceae
Juniperus virginiana L.

Magnoliaceae
Illicium anisatum L.

Calycanthaceae
Calycanthus floridus L.

Anemonaceae
Clematis floribunda Planch. et Triana

Rosaceae
Corchorus japonicus Thunbg. = *Kerria japonica* (L.) DC.
Crataegus nigra W. et K.
— *oxyacantha* L.
Potentilla fruticosa L.
Prunus Mahaleb L. = *Cerasus M.* (L.) Mill.
— *Padus* L. = *Padus avium* Mill.
— *serotinus* Ehrh. = *Padus s.* (Ehrh.) Borkh.
Pyrus aria (L.) Ehrh. = *Sorbus a.* (L.) Cr.
— *Aucuparia* (L.) Gärtn. = *Sorbus A.* L.
— *malus spectabilis alba* + *rubra* = *Malus* s. (Ait.) Borkh. cv.
— *salicifolia* Pall.
— *amydaliformis* Vill.
Rubus odoratus L.
Spiraea chamaedryfolia L.
— *crenata* L.
— *japonica* L. f.

Saxifragaceae
Bauera rubioides Andr.

Hydrangeaceae
Philadelphus coronarius L.

Pittosporaceae
Pittosporum revolutum
Pittosporum Tobira (Thunb.) Ait.

Caesalpiniaceae
Cassia riparia H. B. K.
Cercis siliquastrum L.

Mimosaceae
Acacia affinis Sweet = *A. dealbata* Link
— *daviesioides* A. Cuun. = *A. diffusa* Lindl.
— *glauca* Moench = *Leucaena* g. Benth.
— *latifolia* Benth.
— *longifolia*
— *prostrata* Lodd. = *A. diffusa* Lindl.

Fig. 2. Bauera rubioides

— *undulata* Willd. = *A. armata* R. BR.
— *verticillata* Willd.

Fabaceae

Amorpha fruticosa L.
Coronilla Emerus L.
Cytisus alpinus Mill. = *Laburnum a.* (Mill.) Bercht et Presl.
— *biflorus* L'Hérit.
— *candicans* Lam.
— *elongatus* W. et K. = *C. biflorus* L'Hérit.
— *Laburnum* L. = *Laburnum anagyroides* Medic.
— *purpureus* Scop.
— *quercifolius hort.* = *Laburnum anagyroides* Medic. cv. *Quercifolium*
— *sessilifolius* L.
Eutaxia myrtifolia R. BR.

Genista canariensis L. = *Cytisus c.* (L.) Kuntze
Glycine frutescens L. = *Wistaria f.* (L.) Poir.
Hedysarum canadense L. = *Desmodium* c. (L.) DC.
Loddigesia oxalidifolia Sims
Ononis Columnae All. = *O. pusilla* L.
— *fruticosa* L.
Pultenaea ternata F. Muell.
Robinia Caragana L. = *Caragana arborescens* Lam.
— *Halodendron* Pall. = *Halimodendron argenteum* Fisch.
— *hispida* L.
Trifolium odoratum Schrank = *T. montanum* L.

Thymelaeaceae

Passerina pendulata Eckl. et Zeyh. = *P. rigida* Wikstr.
Pimelea arenaria A. Cunn.

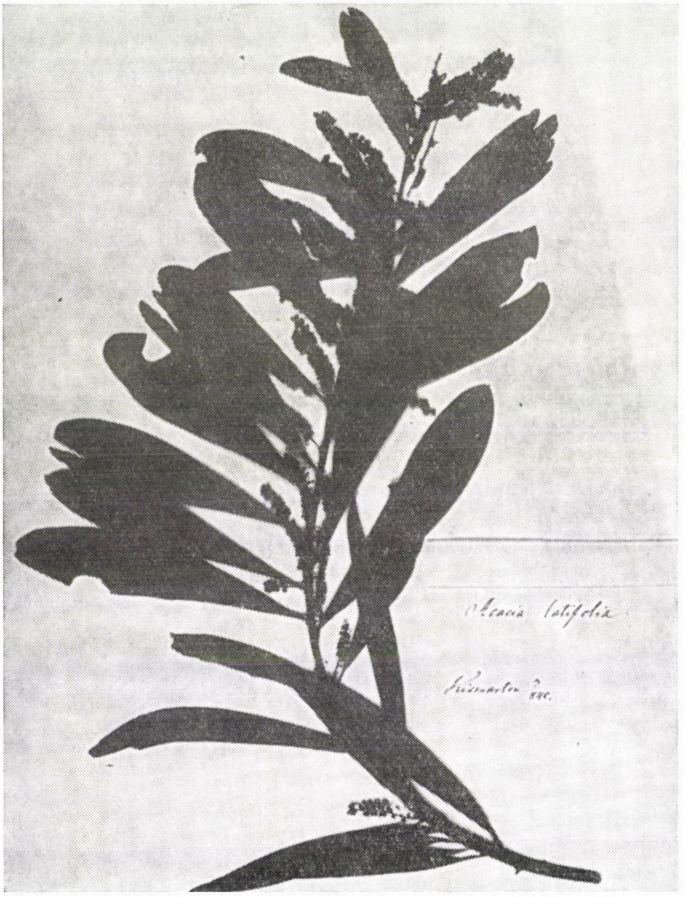


Fig. 3. Acacia latifolia

Fig. 4. Acacia longifolia

Myrtaceae

Callistemon speciosus DC. = *Metrosideros s.* (DC.) Sims
Calothamnus clavatus Mackay = *C. quadrifidus* Ait.
Leptospermum juniperinum SM. = *L. scoparium* Forst.
Melaleuca cordata Benth.
— *hypericifolia* Smith
Myrtus communis L.

Punicaceae

Punica granatum L.

Rutaceae

Borina pendula ?
Diosma ciliata L. = *Agathosma c.* (L.) Link
— *umbellata* Thunb. = *Agathosma u.* (Thunb.) Sond.
Ptelea trifoliata L.

Anacardiaceae

Rhus Cotinus L. = *Cotinus coggygria* Scop.
— *succedanea* L.

Aceraceae

Acer monspessulanus L.
— *palmatum* Thunb.
— *pseudoplatanus* L.
— *striatum* DuRoi = *A. spicatum* Lam.
— *tataricum* L.

Hyppocastanaceae

Aesculus flava Ait. = *Ae. octandra* Marsh.
— *Pavia* L.

Staphyleaceae

Staphylea pinnata L.

Rhamnaceae

Paliurus aculeatus Lam. = *P. Spina-Christi* Mill.
Rhamnus Alaternus L.

Cornaceae

Cornus alba L.

Rubiaceae

Serissa japonica Thunb. = *S. foetida* Lam.

Caprifoliaceae

Viburnum Lanatum L.
— *prunifolium* L.

Valerianaceae

Fedia scorpioides = *Valeriana* s. DC.

Tiliaceae

Tilia americana L.

Malvaceae

Anoda Dilleniana Cav. = *A. lavateroides* Medic.
Hibiscus Rosa-sinensis L.

Sterculiaceae

Thomasia dumosa hort. = *Rulingia parviflora* Endl.
— *solanacea* J. Gay.

Euphorbiaceae

Euphorbia carnea ?
Xylophylla angustifolia

Oleaceae

Jasminum fruticans L.
— *gracile* Andr. = *J. simplicifolium* Forst.
— *triumphans?* (ev.?)

Asclepiadaceae

Hoya carnosa (L. f.) R. BR.
Periploca graeca L.

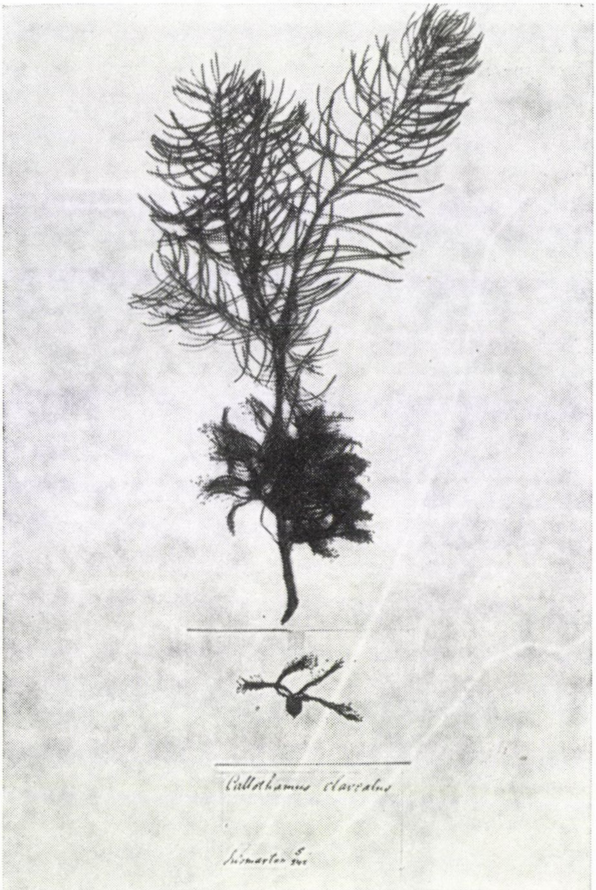


Fig. 5. Calothamnus clavatus

Polemoniaceae

Phlox Drummondii Hook.

Verbenaceae

Tournefortia heliotropioides Hook. = *Heliotropium anchusaefolium* Poir.

Boraginaceae

Echium giganteum L.

Scrophulariaceae

Anarrhinum bellidifolium Desf.
Collinsia bicolor
Mimulus glutinosus Wendl. = *M. aurantiacus* Curt.
— *quinquevulnerus ?*
Selago corymbosa L.
Veronica crenata Lodd.

Bignoniaceae

Bignonia radicans L. = ***Campsis r.*** **(L.) Seemann**

Acanthaceae

Ruellia coccinea

Papaveraceae

Capparis frondosa Jacq.

Loasaceae

Scyphanthus elaeagnus D. Don. = ***Grammatocarpus volubilis*** **Presl**

Begoniaceae

Begonia argyrostigma Fisch. = ***B. maculata*** **Raddi**
— *heracleifolia* Cham. et Schlecht.
— *sanguinea* Raddi

Dilleniaceae

Hibbertia grossulariaefolia Salisb.

Campanulaceae

Canarina campanulata L.

Compositae

Athanasia flammea ? = *Arctotis f.* Jacq.
Chrysanthemum Leucantnemum L.
Eupatorium lathyroides ?
Gnaphalium rectum C. A. Mey = ***G. supinum*** **L.**
— *linifolium ?*
— *margaritaceum* L. = ***Anaphalis m.*** **(L.) Benth.**
Prenanthes purpurea L.
Rudbeckia purpurea L. = ***Echinacea p.*** **(L.) Moench**
Senecio nemorensis **L.**

Ericaceae

Andromeda buxifolia Lam. = ***Agauria b.*** **(L.) Bak.**
Azalea pontica L. = ***Rhododendron flavum*** **(Hoffm.) G. Don**
Epacris paludosa R. BR.
— *obtusifolia* SM.
Erica arborea L.
— *vulgaris* L. = ***Calluna v.*** **(L.) Hull.**

Aizoaceae

Mesembryanthemum spectabile Haw. = ***Lampranthus s.*** **(Haw.) N. E. BR.**

Theophrastaceae

Theophrasta longifolia Jacq. = ***Clavija ornata*** **D. Don**

Plumbaginaceae

Plumbago rosea L.

Polygonaceae

Rheum rhabarbarum L. = ***Rh. undulatum*** **L.**

Moraceae

Morus papyrifera L. = ***Broussonetia p.*** **(L.) L'Hérit.**

Liliaceae

Dianella coerulea Sims
Ornithogalum narbonense L.
Xanthorrhoea rotundifolia

Iridaceae

Gladiolus communis L. = *G. byzantinus* Mill.

From József Jemelka's collection:

Viola elatior Fries	*Goodyera discolor* Ker-Gawl. = *Haemaria d.* Lindl.
— *canina* L.	*Cypripedium guttatum* SW.
— *mirabilis* L.	*Allium ursinum* L.

The list reveals that the collection included greenhouse species from Australia and from South-America, including ones which are missing from the present botanical gardens. After the long period which has passed since the collection was made, these are the species left in the herbarium, and this gives the work of selection its special character. It would be interesting to know whether there are any further plants from Kismarton in Rómer's other herbaria.

The picture of this famous Esterházy garden is not complete. But it suffices to show that the gardens of that time reached a very high standard. This garden deserved its fame and was rightly compared to the most beautiful gardens and parks of Europe.

Acknowledgements

The author is indebted to Mr. Szaniszló Priszter for his verbal information and for his kind help in compiling the nomenclature.

*

Prepared at the Botanical Department of the Teachers' Training College, Pécs.

L. Zs. Vöröss

References

Rapaics, R. (1940): Magyar kertek (Hungarian gardens). Kir. Magy. Egyetemi Nyomda, Budapest.

VIRUSES OF LETTUCE

II. Host Ranges of Lettuce Mosaic Virus and Cucumber Mosaic Virus

In the first part of our publication series (Horváth 1980) various viruses pathogenic to lettuce were presented and it was pointed out that the lettuce mosaic virus, */* : */* : E/E : S/Ap, potyvirus group, and the cucumber mosaic virus, R/1 : 1/18 : S/S : S/Ap, cucumovirus group, are the most frequently occurring and economically most important of them. The different host plants are of very great importance in the natural circulation of viruses transmitted by aphids in a stylet-borne manner. However, the virus hosts are of invaluable significance not only from an epidemiological point of view; they are also indispensable in identifying the viruses. Plants resistant to viruses, on the other hand, have a role first in breeding for resistance, and secondly in virus separation.

A number of papers have been published so far on various hosts of the lettuce mosaic virus (WILKINSON—HIRSCH 1952, COSTA—DUFFUS 1958, KLINKOWSKI—USCHDRAWEIT 1968, KEMPER 1962, TOMLINSON 1964, 1970, RYDER 1970, PURCIFULL—ZITTER 1971, RAGOZZINO *et al.* 1971, SCHMELZER—WOLF 1971, PROVVIDENTI—SCHROEDER 1972, PROVVIDENTI 1973, EDWARDSON 1974, LISA—LOVISOLO 1976, SCHMELZER—WOLF 1977, SCHMELZER *et al.* 1977), but not a single work containing a detailed description of the host range of the virus and of the plants resistant to it has appeared.

The first noteworthy report on the host range of cucumber mosaic virus was presented by the American virologist PRICE (1940). This work, which discusses the virus susceptibility of nearly 300 species of 64 plant families was unique at that time in plant virology. A quarter of a century later KOVACHEVSKY (1965) described further hosts susceptible to cucumber mosaic virus (91 species of 22 plant families). The following year a book was published by THORNBERRY (1966) who, using Price's data too, gave an account of some 350 plants susceptible to cucumber mosaic virus. Following Thornberry the late Dr. K. Schmelzer (1928—1976), German virologist, described further virus hosts of great scientific importance (SCHMELZER—SCHMIDT 1968, SCHMELZER 1970, 1974) as a continuation of his dissertation "Untersuchungen an Viren der Zier- und Wildgehölze" (SCHMELZER 1962a, b, c, d). Further investigations (SHUKLA—SCHMELZER 1970, 1973, 1975), in the course of which some 72 so-far unknown cruciferous ornamental and wild plants susceptible to cucumber mosaic virus were detected, were of similarly invaluable importance for science. During the 1965—1974 period KOVACHEVSKY (1976) demonstrated twenty new natural hosts of cucumber mosaic virus in Bulgaria. It is due to the extensive scientific and literary work of SCHMELZER—WOLF (1977) and SCHMELZER *et al.* (1977) that almost the full range of hosts to cucumber mosaic virus has become known. Our own investigations (HORVÁTH 1976, 1979b) in recent years have led to the identification of about 131 new hosts of cucumber mosaic virus and of numerous plants resistant to it.

The present paper is aimed at giving a fully comprehensive view of the host ranges of lettuce mosaic virus and cucumber mosaic virus and of the plants resistant to them, using all the information obtained so far, and taking the most recent results into consideration.

Natural hosts of lettuce mosaic virus

As far as we are aware and according to the available literature, members of the following 9 taxonomic plant families are recorded as natural hosts of the lettuce mosaic virus (Table 1). These are the following 21 species related to 19 genera:

Caryophyllaceae: *Stellaria media*

Chenopodiaceae: *Chenopodium album, C. murale, Spinacia oleracea*

Compositae (Asteraceae): *Carduus broteroi, Cichorium endivia, Lactuca sativa, L. virosa, Picris echioides, Senecio vulgaris, Sonchus asper, Urospermum picroides, Zinnia elegans*

Cruciferae (Brassicaceae): *Capsella bursa-pastoris*

Fabaceae (Luguminosae, Papilionaceae): *Lathyrus odoratus, Pisum sativum*

Geraniaceae: *Erodium cicutarium*

Table 1

Number of natural and artificial hosts of lettuce mosaic virus and of resistant plants in the various plant families

Family	Natural hosts	Artificial hosts	Resistant plants
Aizoaceae	—	4	—
Amaranthaceae	—	2	—
Boraginaceae	—	1	—
Caryophyllaceae	1	1	—
Chenopodiaceae	3	11	1
Compositae (Asteraceae)	9	82	8
Cruciferae (Brassicaceae)	1	2	6
Cucurbitaceae	—	2	13
Fabaceae (Leguminosae, Papilionaceae)	2	5	9
Geraniaceae	1	1	—
Gramineae (Poaceae)	—	—	1
Labiatae (Lamiaceae)	1	1	6
Malvaceae	1	1	1
Martyniaceae	—	1	—
Nolanaceae	—	—	2
Polygonaceae	—	1	—
Primulaceae	2	3	—
Ranunculaceae	—	—	1
Scrophulariaceae	—	—	1
Solanaceae	—	3	8
Umbelliferae (Apiaceae)	—	—	4

Labiatae (Lamiaceae): *Lamium aplexicaule*

Malvaceae: *Malva parviflora*

Primulaceae: *Anagallis arvensis, Primula obconica.*

Among the spontaneous, natural host plants the cultivated, economically important vegetables (e.g. *Lactuca sativa, Pisum sativum, Spinacia oleracea*), the overwintering hosts (e.g. *Cichorium endivia*) and some particularly wide-spread weeds (e.g. *Capsella bursa-pastoris, Senecio vulgaris, Sonchus asper, Stellaria media*) are undoubtedly the most important.

Artificial hosts of lettuce mosaic virus

On the other hand, the published literature (JAGGER 1921, WILKINSON—HIRSCH 1952, ULLRICH 1954, COSTA—DUFFUS 1958, NITZANY—COHEN 1960, KEMPER 1962, TOMLINSON 1964, 1970, KLINKOWSKI—USCHDRAWEIT 1968, RYDER 1970, PURCIFULL—ZITTER 1971, RAGOZZINO *et al.* 1971, SCHMELZER—WOLF 1971, PROVVIDENTI—SCHROEDER 1972, PROVVIDENTI 1973, ZINK *et al.* 1973, EDWARDSON 1974, LISA—LOVISOLO 1976, SCHMELZER *et al.* 1977, HORVÁTH 1979a) points out that members of 16 taxonomic plant families have proved to be artificial hosts of the lettuce mosaic virus (Table 1). These are the following 121 species related to 60 genera:

Aizoaceae: *Tetragonia crystallina*, T. echinata, T. eremaea*, T. expansc*

Amaranthaceae: *Gomphrena decumbens*, G. globosa*

* Denotes new artificial hosts of lettuce mosaic virus (HORVÁTH 1979a)

Boraginaceae: *Anchusa officinalis*

Caryophyllaceae: *Stellaria media*

Chenopodiaceae: *Beta vulgaris* var. *cicla viridis, Chenopodium album, C. amaranticolor, C. ambrosioides, C. aristatum, C. capitatum, C. murale, C. quinoa, C. rubrum, C. urbicum, Spinacia oleracea*

Compositae (Asteraceae): *Ammobium alatum, Anacyclus clavatus, A. officinarum, Anthemis arvensis, A. tinctoria, Aster* sp., *Baeria californica, B. maritima, Bellis perennis, Brachycome iberidifolia, B. pachyptera, Calendula algeriensis, C. arvensis, C. fulgida, C. officinalis, Callistephus chinensis, Carduus broteri, Carthamus lanatus*, C. tinctorius, Centaurea solstitialis, Chrysanthemum coronarium, C. segetum, Cichorium endiva, C. intybus, Cladanthus arabicus, Coreopsis tinctoria, Crepis setosa, Dimorphotheca aurantiaca, D. pluvialis, D. sinnata, Emilia coccinea, Felicia amelloides, Galinsoga ciliata, G. parviflora, Guizothia abyssinica, Helipterum roseum, Lactuca altaica, L. angustana, L. dissecta, L. gracoglossum, L. kochiana, L. livida, L. longifolia, L. macrorhiza, L. muralis, L. perennis, L. paddeana, L. quercina*, L. saligna, L. sativa, L. sativa* convar. *inocta* var. *capitata* "Cazard Grosser Gelber"*, *L. sativa* var. *capitata, L. sativa* var. *romana, L. scariola, L. scariola* var. *integrata, L. serriola, L. tatarica*, L. tuberosa, L. virosa, Mycelis muralis, Picris echioides, Senecio cruentus, S. vulgaris, Silybium marianum, Sonchus asper, S. glaucescens, S. oleraceus, Tagetes erectus, Taraxacum bicorne, T. officinale, Tolpis barbata, Tragopogon porrifolius, Urospermum picroides, Zinnia elegans, Z. haageana, Z. haageana* cv. *Cocarde*, Z. multiflora, Z. pauciflora, Z. pumila*, Z. tenuiflora*, Z. verticillata*, Xerantheum annuum*

Cruciferae (Brassicaceae): *Capsella bursa-pastoris, Iberis umbellata*

Cucurbitaceae: *Cucurbita maxima* cv. *Nugget, C. pepo*

Fabaceae (Leguminosae, Papilionaceae): *Lathyrus odoratus, Melilotus italicus, Phaseolus vulgaris, Pisum sativum, Trifolium incarnatum*

Geraniaceae: *Erodium cicutarium*

Labiatae (Lamiaceae): *Lamium aplexicaule*

Malvaceae: *Malva parviflora*

Martyniaceae: *Proboscidea jussieui*

Polygonaceae: *Rumex britannica*

Primulaceae: *Anagallis arvensis, Primula malacoides, P. obconica*

Solanaceae: *Nicotiana benthamiana, N. clevelandii, N. tabacum*

Plants resistant against infection with lettuce mosaic virus

Among the tested plants the following 61 species of 37 genera and 13 families (see Table 1) proved to be resistant to infection with the virus:

Chenopodiaceae: *Beta vulgaris*

Compositae (Asteraceae): *Carduus arvensis, Centaurea cyanus, Cineraria cruenta, Cynara scolymus, Helianthus annuus, Sonchus arvensis, S. oleraceus, Taraxacum officinale*

Cruciferae (Brassicaceae): *Brassica oleracea* var. *capitata, B. oleracea* var. *botrytis, B. oleracea* var. *botrytis cymosa, B. pekinensis, B. rapa, Raphanus sativus*

Cucurbitaceae: *Citrullus lanatus, Cucumis metuliferus, C. sativus, C. ficifolia, C. lundeniana, C. maxima, C. mixta, C. moschata, Cyclanthera pedata, Lagenaria leucantha, L. siceraria, Luffa acutangula, Momordica charantia*

Fabaceae (Leguminosae, Papilionaceae): *Canavalia gladiata, Melilotus alba, Phaseolus limensis, P. vulgaris, Trifolium hybridum, T. pratense, T. repens, Vicia faba, Vigna sinensis*

Gramineae (Poaceae): *Zea mays*

Labiatae (Lamiaceae): *Ocimum basilicum, O. canum, O. carnosum*, O. sanctum*, O. selloi, O. viride* (BESADA—HORVÁTH 1980)

Malvaceae: *Gossypium herbaceum*

Nolanaceae: *Nolana paradoxa*, N. prostrata**

Ranunculaceae: *Clematis* sp.

Solanaceae: *Datura stramonium, Lycopersicon esculentum, Nicotiana glutinosa, N. hybrida, N. rustica, N. tabacum, N. sylvestris, Petunia hybrida*

Scrophulariaceae: *Antirrhinum majus*

Umbelliferae (Apiaceae): *Apium graveolens, Daucus carota, Pastinaca sativa, Petroselinum hortense.*

The reports on the hosts of lettuce mosaic virus are contradictory in the case of some plants. For example, according to THORNBERRY (1966), who summarized the results of various authors *Sonchus oleraceus* and *Taraxacum officinale* are resistant plants, in opposition to the data of SCHMELZER—WOLF (1971) and SCHMELZER *et al.* (1977). According to the literary data there are differences in virus susceptibility not only between the plant species but also between the varieties; e.g. PROVVIDENTI—SCHROEDER (1972) found *Cucurbita maxima* cv. *Nugget* and *Phaseolus vulgaris* cv. *Bountiful* (and 11 other varieties) to be susceptible, while in the experiments of COSTA—DUFFUS (1958) and PROVVIDENTI—SCHROEDER (1972) other varieties of *C. maxima* and *P. vulgaris* proved resistant to inoculation with lettuce mosaic virus.

Natural hosts of cucumber mosaic virus

As far as we are aware and according to the available literature, members of the following 67 taxonomic plant families are recorded as natural hosts of the cucumber mosaic virus (Table 2). These are the following 476 species related to 257 genera:

Aizoaceae: *Tetragonia tetragonoides*

Amaranthaceae: *Alternanthera ficoidea, Amaranthus retroflexus, A. viridis* (JOSHI—DUBEY 1976)

Amaryllidaceae: *Brunsvigia rosea, Hippeastrum equestre, H. Hybrids, Narcissus pseudonarcissus, N. tazetta, Nerine flexuosa*

Apocinaceae: *Allamanda cathartica, Cathranthus roseus* (syn.: *Vinca rosea*), *Lochnera rosea* (syn.: *Vinca rosea*), *Nerium oleander, Vinca minor, V. rosea* (syn.: *Catharanthus roseus, Lochnera rosea*)

Araceae: *Anthurium andreanum, Zantedeschia* sp.

* Denotes new resistant plant against lettuce mosaic virus (HORVÁTH 1979a)

Aristolochiaceae: *Aristolochia clematitis, A. durior, A. elegans*, A. macrophylla**

Asclepiaceae: *Asclepias curassavica, A. syriaca*

Balsaminaceae: *Impatiens balsamina, I. parviflora, I. walleriana*

Begoniaceae: *Begonia semperflorens, B. tuberhybrida*

Berberidaceae: *Berberis thunbergii, Nandina domestica*

Boraginaceae: *Anchusa* sp., *Mertensia virginiana, Myosotis alpestris, M. scorpioides, Onosma stellulatum, Pulmonaria mollis*

Buxaceae: *Pachysandra terminalis*

Campanulaceae: *Campanula glomerata, C. persicifolia, C. portenschlagiana, C. pyramidalis, C. rapunculoides* (Polák 1964), *C. siphilitica, C. trachelium*

Cannabinaceae: *Cannabis sativa*

Caprifoliaceae: *Leycesteria formosa, Lonicera periclymenum, Sambucus canadensis, S. nigra, Viburnum opulus*

Caryophyllaceae: *Dianthus carthusianorum, D. caryophyllus, Lychnis chalcedonica* (Kovachevsky 1976), *Melandrium album* (syn.: *Silene alba*), *Silene alba* (syn.: *Melandrium album*), *S. cucubalus, Stellaria media, Viscaria vulgaris* (Kovachevsky 1976)

Chenopodiaceae: *Atriplex patula* (Kovachevsky 1976), *Beta vulgaris* var. *altissima, B. vulgaris* var. *cicla, Chenopodium polyspermum, Spinacia oleracea*

Cistaceae: *Helianthemum grandiflorum*

Commelinaceae: *Commelina gigas, C. nudiflora, C.* sp., *Tradescantia fluminensis*

Compositae (Asteraceae): *Arctium lappa, Artemisia absinthium, Calendula officinalis, Callistephus chinensis, Carthamus tinctorius, Centaurea arbutifolia, C. canariensis, C. canariensis* var. *subexpinnata, C. cyanus, C. imperialis, C. webbiana, Cichorium endivia, C. intybus, Coreopsis* sp., *Cynara cardunculus, Dahlia variabilis, Doronicum cordifolium, Doronicum orientale, D. plantagineum, Echinacea purpurea, Gaillardia aristata, Galinsoga parviflora, G. quadriradiata, Helenium autumnale, H. hooperi* (Kovachevsky 1976), *Heliopsis helianthoides, Hieracium* sp., *Lactuca sativa, Ligularia clivorum, L. kaempferi* (syn.: *L. tussilaginea*), *L. tussilaginea* (syn.: *L. kaempferi*), *Matricaria* sp., *Scorzonera hispanica, Senecio jacobaea, S. kaempferi, S. praealta, S. vulgaris, Silphum perfoliatum, Silybum marianum, Sonchus oleraceus, Stenactis strigosa* (Salamon 1979), *Stokesia leavis, Taraxacum officinale* (Kovachevsky 1976), *Tripleurospermum maritima, Xanthium orientale, Zinnia elegans*

Convolvulaceae: *Convolvulus arvensis, Dichondrea repens, Ipomoea* sp.

Crassulaceae: *Sedum populifolium*

Cruciferae (Brassicaceae): *Aethionema grandiflorum, A. pulchellum, Alliaria officinalis* (syn.: *A. petiolata*), *A. petiolata* (syn.: *Alliaria officinalis*), *Alyssoides utriculatum, Alyssum bornmuelleri, A. saxatile, A. spinosum, Arabis alpestris, A. blepharophylla, A. caerulea, A. caucasica, A. jacquinii, A. muralis, A. scopoliana, A. stelleri, A. sudetica, A. vochinensis, Aubrieta deltoides, A. deltoides* var. *graeca, A. erubescens, A. hesperidiflora, A. intermedia, A. italica, A. olympica, A. pinardi, A. suendermanii, Barbarea iberica, B. intermedia, B. lyrata, B. vulgaris, Berteroa incana, Biscutella lyrata, B. raphanifolia, Brassica juncea, B. napus*, B. napus* var. *napobrassica, B. nigra, B. oleracea* var. *sabellica, B. rapa* var. *campestris, B. rapa* var.

* Denotes new natural host of cucumber mosaic virus (Horváth 1976)

rapa, Brassicella erucastrum, Bunias erucago, B. orientalis, Cakile maritima, Capsella bursa-pastoris, C. grandiflora, Cardamine pratensis, Cheiranthus cheiri, Cochlearia glastifolia, C. officinalis, Crambe maritima, Draba aizoides, D. daurica, D. hispida, D. hoppeana, D. loiseleurii, D. longirostra, D. sibirica, Eruca sativa, Erysimum helveticum, E. hieraciifolium, E. ochroleucum, E. odoratum, E. perovskianum, E. pumilum, Fibigia clypeata, Hesperis matronalis, H. steveniana, H. tristis, Hutchinsia alpina, H. brevicaulis, Iberis amara, I. umbellata, Isatis tinctoria, Lepidium stalatum, Lobularia maritima, Lunaria annua, Malcolmia bicolor, Matthiola incana, M. vallesiaca, Peltaria alliacea, Raphanus raphanistrum, R. sativus, Rapistrum rugosum, Rorippa nasturtium-aquaticum, R. silvestris, Schivereckia podolica, Schizopetalon walkeri, Sinapis alba (Kovachevsky 1976), *Sinapis arvensis, Sisymbrium irio, S. loeselii, S. officinale, Thlaspi arvense, T. bellidifolium, T. montanum, Vesicaria utriculata.*

Cucurbitaceae: *Citrullus lanatus* (syn.: *C. vulgaris*), *C. vulgaris* (syn.: *C. lanatus*), *Cucumis anguria, C. melo, C. sativus, Cucurbita maxima, C. pepo, C. pepo* convar. *patissonina* f. *radiata**, *Echinocystis lobata* (syn.: *Micrampelis lobata*), *Luffa cylindrica, Melothria pendula, Micrampelis lobata* (syn.: *Echinocystis lobata*)

Dilleniaceae: *Hibbertia scandens*

Ericaceae: *Cassiope hypnoides*

Euphorbiaceae: *Croton lobatus* (Migliori *et al.* 1977), *Euphorbia corollata, E. salicifolia* (Salamon 1979), *Mercurialis annua*

Fabaceae (Leguminosae, Papilionaceae): *Cicer arietinum, Corydalis lutea, Cytisus laburnum* (Kovachevsky 1976), *Lathyrus japonicus* (Kovachevsky 1976), *Lupinus albococcineus* (Kovachevsky 1976), *L. angustifolius, L. aridus* (Kovachevsky 1976), *L. luteus, L. mutabilis, L. palustris* (Kovachevsky 1976), *Medicago lupulina* (Kovachevsky 1976), *M. sativa, Phaseolus lunatus, P. lunatus* f. *macrocarpus, Pisum sativum, Sophora japonica* (Kovachevsky 1976), *Thermopsis caroliniana, Trifolium alexandrinum, T. hybridum, Trigonella coerulea* (Kovachevsky 1976), *Vicia siccula* (Kovachevsky 1976), *Vigna hosei* (Migliori *et al.* 1977), *V. radiata* (Purivirojkul—Poehlman 1977), *V. sinensis*

Gentianaceae: *Gentiana cruciata, G. kurroo, G. lutea, G. pannonica, G. septemfida, G. tibetica*

Geraniaceae: *Geranium carolinianum, G. rotundifolium, Pelargonium hortorum*

Gesneriaceae: *Saintpaulia* sp. (Kovachevsky 1976)

Helleboraceae: *Eranthis hyemalis, Helleborus niger, Trollius asiaticus, T. chinensis, T.* × *cultorum, T. europaeus, T.* sp.

Hydrangeaceae: *Philadelphus* × *falconeri*

Iridaceae: *Crocus* sp., *Gladiolus* sp., *Iris germanica*

Labiatae (Lamiaceae): *Ajuga reptans, Ballota nigra, Hyssopus officinalis, Lamium album, L. amplexicaule, L. galeobdolon, L. purpureum, L.* sp., *Leonurus cardiaca, Mentha piperita, M.* sp., *M. spicata, Molucella laevis, Nepeta cataria, Ocimum basilicum, Rosmarinus officinalis, Salvia lyrata, S. nemorosa, S. plebeia, S. pratensis, S. splendens, Scutellaria alpina, Stachys palustris, Teucrium chamaedrys*

Liliaceae: *Asparagus officinalis, Gloriosa superba, Lilium candidum, L. croceum, L. longiflorum, L. tigrinum, Tulipa* sp.

Loganiaceae: *Buddleia davidii*

Magnoliaceae: *Magnolia* sp.

Malvaceae: *Hibiscus esculentus, Malva sylvestris*

Martyniaceae: *Martynia louisiana*

Moraceae: *Maclura pomifera*

Musaceae: *Musa acuminata* (syn.: *M. cavendishii*), *M. cavendishii* (syn.: *M. acuminata*), *M. paradisiaca* (syn.: *M. sapientum*), *M. sapientum* (syn.: *M. paradisiaca*)

Oleaceae: *Chionanthus virginicus, Ligustrum* sp., *L. vulgare*

Onagraceae (Oenotheraceae): *Circaea lutetiana**

Orchidaceae: *Dendrobium* sp.

Papaveraceae: *Chelidonium majus, Romneya coulteri*

Passifloraceae: *Passiflora coerulea, P. edulis*

Pedaliaceae: *Sesamum orientale* var. *albidum* (KOVACHEVSKY 1976)

Phytolaccaceae: *Phytolacca americana* (syn.: *P. decandra*), *P. decandra* (syn.: *P. americana*)

Piperaceae: *Peperomia glabella, P. tithymaloides, Piper nigrum*

Polemoniaceae: *Phlox divaricata, P. paniculata, Polemonium caeruleum, P. lanatum, P. reptans*

Polygonaceae: *Polygonum persicaria, Rheum* sp., *Rumex acetosa*

Portulacaceae: *Portulaca oleracea*

Primulaceae: *Androsace septentrionalis, Dodecatheon jeffreyi, Douglasia vitaliana, Primula acaulis, P. alpicola, P. auricula, P. bulleyana, P. burmanica, P. cortusoides, P. denticulata, P. elatior, P. farinosa, P. helenae, P. japonica, P. juliae, P. malacoides, P. moerheimi, P. nutans, P. obconica, P. polyantha, P. pruhoniciana, P. pulverulenta, P. rosea, Soldanella montana*

Ranunculaceae: *Anemone coronaria, A. hepatica, A. japonica, A. sylvestris, Aquilegia alpina, A. caerulea, A. canadensis, A. chrysantha, A. flabellata, A. haylodgensis, A. vulgaris, Delphinium ajacis, D. cashmerianum, D. consolida, D. elatum, D. grandiflorum, D. sinense, D.* sp., *Ranunculus abortivus, R. adscendens, R. repens*

Rhamnaceae: *Rhamnus cathartica*

Rosaceae: *Coluria geoides, Prunus armeniaca* (V. NÉMETH 1978, personal communication), *P. avium, P. cerasus, P. domestica, P. persica, Rubus idaeus*

Saxifragaceae: *Hydrangea macrophylla, Ribes aureum, R. nigrum, Saxifraga aquatica, S. rotundifolia*

Scrophulariaceae: *Digitalis lanata* (KOVACHEVSKY 1976), *D. lutea, Paulownia imperialis* (syn.: *P. tomentosa*)*, *P. tomentosa* (syn.: *P. imperialis*)*, *Pentstemon gentianoides* (KOVACHEVSKY 1976), *Scoparia dulcis, Scrophularia nodosa, S. umbrosa*

Solanaceae: *Capsicum annuum, C. frutescens, Cyphomandra betacea, Datura ferox, D. stramonium, Lycium chinense, L. halimifolium, Lycopersicon esculentum, L. pimpinellifolium, Nicotiana affinis* (KOVACHEVSKY 1976), *N. glauca, N. plumbaginifolia* (JOSHI—DUBEY 1976), *N. tabacum, Petunia hybrida, Physalis angulata, P. minima* (JOSHI—DUBEY 1976), *P. peruviana, P. pubescens, P. wrightii, Scopolia carniolica*, Solanum dulcamara* (SALAMON 1979), *S. eleagnifolium, S. gracile, S. melongena, S. nigrum, S. tuberosum, Withania somnifera*

Thymeleaceae: *Daphne mezereum, D. odora*

Tropaeolaceae: *Tropaeolum majus*

Umbelliferae (Apiaceae): *Ammi majus, Anethum graveolens, Angelica archangelica, Apium graveolens* var. *dulce, A. graveolens* var. *rapaceum, Astrantia minor, Bupleurum falcatum, Cicuta virosa, Coriandrum sativum, Daucus carota, Eryngium amethystinum, E. campestre, E. dichotoma, E. giganteum, E. lassauxii, E. planum, E. yuccifolium, Heracleum lanatum, Ligusticum scoticum, Oenanthe pimpinelloides, Pastinaca sativa, Petroselinum crispum, Peucedanum* sp., *Pimpinella anisum, Sanicula europaea, Sium erectum, Smyrnium olusatrum*

Urticaceae: *Urtica urens*

Valerianaceae: *Centrantus ruber, Valeriana officinalis, Valerianella locusta*

Verbenaceae: *Caryopteris clandonensis*

Violaceae: *Viola odorata, V. sepincola, V. tricolor, V. wittrockiana.*

Artificial hosts of cucumber mosaic virus

The published literature indicates that the cucumber mosaic virus was found to be infectious to members of 53 plant families (Table 2). In the following the 536 susceptible plant species, related to 106 genera are listed:

Acanthaceae: *Ruellia tuberosa*

Aizoaceae: *Dorotheanthus bellidiformis, Mesembryanthemum crystallinum, Mollugo verticillata, Tetragonia crystallina*, T. echinata*, T. eremaea* (HORVÁTH 1977, unpublished), *T. expansa* (syn.: *T. tetragonoides*), *T. tetragonoides* (syn.: *T. expansa*)

Amaranthaceae: *Amaranthus angustifolius* (syn.: *A. graecizans*)*, *A. ascendens* (syn.: *A. lividus* var. *ascendens*)*, *A. atropurpureus* (syn.: *A. hybridus*)*, *A. aureus* (syn.: *A. paniculatus* var. *flavus*)*, *A. bouchoni*, A. caracu* (syn.: *A. hypochondriacus*)*, *A. caudatus, A. caudatus* cv. *Atripurpureus* (syn.: *A. caudatus* var. *sanguineus*)*, *A. caudatus* var. *sanguineus* (syn.: *A. caudatus* cv. *Atripurpureus*)*, *A. chlorostachys* (syn.: *A. hybridus*)*, *A. chlorostachys* f. *leucocarpus* (syn.: *A. chlorostachys* f. *strictus*)*, *A. chlorostachys* var. *leucocarpus* (syn.: *A. leucocarpus*)*, *A. chlorostachys* f. *strictus* (syn.: *A. chlorostachys* f. *leucocarpus*)*, *A. chlorostachys* var. *powelli*, A. cruentus* (syn.: *A. paniculatus*)*, *A. deflexus*, A. deflexus* var. *rufescens*, A. dubius*, A. emarginatus* (syn.: *A. lividus* var. *ascendens*)*, *A. gangeticus* var. *multicolor* (syn.: *A. tricolor*)*, *A. graecizans* (syn.: *A. graecizans* var. *sylvestris, A. sylvestris*)*, *A. graecizans* var. *sylvestris* (syn.: *A. graecizans*)*, *A. graecizans* var. *sylvestris* (syn.: *A. sylvestris*)*, *A. hybridus* (syn.: *A. atropurpureus*)*, *A. hybridus* (syn.: *A. chlorostachys*), *A. hypochondriacus* (syn.: *A. caracu*)*, *A. hypochondriacus* cv. *Monstrosus*, A. leucocarpus* (syn.: *A. chlorostachys* var. *leucocarpus*)*, *A. lividus* (syn.: *A. lividus* var. *ascendens*)*, *A. lividus* var. *ascendens* (syn.: *A. ascendens*)*, *A. lividus* var. *ascendens* (syn.: *A. emarginatus*)*, *A. lividus* var. *ascendens* (syn.: *A. lividus*)*, *A. lividus* var. *oleraceus* (syn.: *A. oleraceus*)*, *A. mantegazzianus*, A. oleraceus* (syn.: *A. lividus* var. *oleraceus*)*, *A. paniculatus* (syn.: *A. cruentus*)*, *A. paniculatus* cv. *Roter Dom*, A. paniculatus* cv. *Roter Paris*, A. paniculatus* cv. *Sanguineus nanus*, A. paniculatus* f. *speciosus* (syn.: *A. speciosus*)*, *A. paniculatus* var. *flavus* (syn.: *A. aureus*)*, *A. speciosus* (syn.: *A. paniculatus* f. *speciosus*)*, *A. spinosus*, A. sylvestris* (syn.: *A. graecizans* var. *sylvestris*)*, *A. tricolor, A. tricolor* (syn.: *A. gangeticus* var. *multicolor*)*, *A. tricolor* cv. *Malten Fire*, A. viridis* (syn.: *A. lividus* var. *ascendens*)*, *Celosia argentea, C. plumosa, Gomphrena decumbens*, G. globosa*

* Denotes new host of cucumber mosaic virus (HORVÁTH 1976, 1979b)

Table 2

Number of natural and artificial hosts of cucumber mosaic virus and of resistant plants in the various plant families

Family	Natural hosts	Artificial hosts	Resistant plants
Acanthaceae	—	1	2
Aizoaceae	1	8	1
Amaranthaceae	3	52	7
Amaryllidaceae	6	—	4
Apocynaceae	5	—	1
Araceae	2	2	2
Aristolochiaceae	4	—	—
Asclepiaceae	2	—	—
Balsaminaceae	3	—	1
Begoniaceae	2	—	1
Berberidaceae	2	—	—
Bignoniaceae	—	1	2
Boraginaceae	6	5	4
Bromeliaceae	—	1	3
Buxaceae	1	—	—
Campanulaceae	7	1	2
Cannabinaceae	1	—	—
Cannaceae	—	2	2
Capparidaceae	—	2	1
Caprifoliaceae	5	—	—
Caricaceae	—	—	1
Caryophyllaceae	8	16	5
Chenopodiaceae	5	8	6
Cistaceae	1	—	1
Commelinaceae	4	9	5
Compositae (Asteraceae)	46	50	37
Convolvulaceae	3	10	9
Crassulaceae	1	1	1
Cruciferae (Brassicaceae)	98	22	29
Cucurbitaceae	12	30	14
Cyperaceae	—	—	2
Dilleniaceae	1	—	—
Dioscoreaceae	—	—	2
Dipsacaceae	—	3	—
Ericaceae	1	—	1
Euphorbiaceae	4	3	7
Fabaceae (Leguminosae, Papilionaceae)	24	26	37
Gentianaceae	6	—	—
Geraniaceae	3	8	10
Gesneriaceae	1	—	1
Gramineae (Poaceae)	—	5	14
Helleboraceae	7	—	—
Hydrangeaceae	1	—	—
Hydrophyllaceae	—	3	2
Iridaceae	3	2	10
Labiatae (Lamiaceae)	24	12	6
Liliaceae	7	21	49
Linaceae	—	—	1
Lobeliaceae	—	3	2
Loganiaceae	1	—	—
Lythraceae	—	1	—
Magnoliaceae	1	—	—
Malvaceae	2	8	9

Table 2 (continued)

Family	Natural	Artificial	Resistant plants
	hosts		
Marantaceae	—	1	—
Martyniaceae	1	—	—
Moraceae	1	1	—
Musaceae	4	6	12
Myrtaceae	—	—	1
Nolanaceae	—	1	—
Nyctaginiaceae	—	1	1
Oleaceae	3	—	—
Onagraceae (Oenotheraceae)	1	4	2
Orchidaceae	1	1	—
Oxalidaceae	—	—	2
Papaveraceae	2	4	4
Passifloraceae	2	7	—
Pedaliaceae	1	1	—
Phytolaccaceae	2	2	2
Piperaceae	3	—	—
Plantaginaceae	—	—	2
Plumbaginaceae	—	—	3
Polemoniaceae	4	4	—
Polygonaceae	4	3	4
Polypodiaceae	—	—	1
Pontederiaceae	—	—	2
Portulacaceae	1	1	1
Primulaceae	24	4	1
Proteaceae	—	—	1
Ranunculaceae	21	6	3
Resedaceae	—	1	1
Rhamnaceae	1	—	—
Rosaceae	7	—	3
Rubiaceae	—	—	1
Rutaceae	—	1	5
Sapindaceae	—	—	1
Saxifragaceae	5	—	2
Scrophulariaceae	8	14	13
Solanaceae	27	149	20
Thymeleaceae	2	—	1
Tropaeolaceae	1	—	1
Typhaceae	—	—	1
Umbelliferae (Apiaceae)	27	6	5
Urticaceae	1	—	—
Valerianaceae	3	—	1
Verbenaceae	1	1	6
Violaceae	4	1	4
Zingiberaceae	—	—	1

Araceae: *Arum italicum, Spathiphyllum* sp.

Bignoniaceae: *Eccremocarpus scaber*

Boraginaceae: *Anchusa italica, Cynoglossum amabile, Echium lycopsis, Heliotropium arborescens, Myosotis sylvatica*

Bromeliaceae: *Ananas comosus*

Campanulaceae: *Campanula medium*

Cannaceae: *Canna indica, C.* sp.

Capparidaceae: *Cleome spinosa, Polanisia trachysperma*

Caryophyllaceae: *Agrostemma githago, Arenaria montana, Dianthus barbatus, D. chinensis, Gypsophila elegans, Lychnis alba, L. chalcedonica, L. haageana-Hybrids, L. viscaria, Melandrium silvestre* (HORVÁTH 1977, unpublished)*, *Saponaria cerastioides*, Silene orientalis, S. pendula*, S. tatarica*, S. vulgaris, Spergula arvensis*

Chenopodiaceae: *Atriplex hortensis, A. sibirica* (syn.: *Obione sibirica*)*, *Beta lomatogona*, B. macrocarpa* (syn.: *B. vulgaris* ssp. *macrocarpa*)*, *B. vulgaris* ssp. *macrocarpa* (syn.: *B. macrocarpa*)*, *Chenopodium album, C. hybridum, Obione sibirica* (syn.: *Atriplex sibirica*)*

Commelinaceae: *Commelina clandestina*, C. communis, C. diffusa, C. elegans, C. erecta, C. graminifolia*, C. tuberosa*, Tradescantia* sp., *Zebrina pendula*

Compositae (Asteraceae): *Ageratum houstonianum, Ambrosia artemisiifolia* var. *elatior, Anthemis arvensis, A. cotula, Arctotis stoechadifolia* var. *grandis, Aster amellus, Bellis perennis, Calendula arvensis, Callistephus hortensis, Centaurea moschata, Chrysanthemum carinatum, C. coronarium, C. hortorum, C. leucanthemum, C. morifolium, C. myconis, C. parthenium, C. segetum, C.* sp., *C. × spectabile, Cichorium endivia, Coreopsis tinctoria, Cosmos bipinnatus, Crassina elegans, Dahlia-Hybrids, D. pinnata, Dimorpotheca sinuata, Emilia sagittata, Eupatorium cannabinum, Gaillardia pulchella* var. *picta, Helenium hoopesii, Helianthus annuus, H. debilis, Helichrysum bracteatum, Helipterum manglesii, H. roseum, Hieracium pilosella, Lactuca scariola* (syn.: *L. serriola*), *L. serriola* (syn.: *L. scariola*), *Lonas annua, Matricaria chamomilla, Rudbeckia hirta, R.* sp., *Senecio viscosus, Tagetes erecta, T. patula, T. tenuifolia, Verbesina encelioides, Zinnia angustifolia, Z. pumila* (HORVÁTH 1977, unpublished)*

Convolvulaceae: *Convolvulus* sp., *C. tricolor, Cuscuta campestris, C. subinclusa, Ipomoea batatas, I. lacunosa, I. nil, I. purpurea, I. trichocarpa, I. tricolor*

Crassulaceae: *Sedum spurium*

Cruciferae (Brassicaceae): *Brassica campestris* var. *napobrassica, B. kaber, B. oleracea* var. *acephala, B. oleracea* var. *botrytis, B. oleracea* var. *capitata, B. oleracea* var. *gemmifera, B. oleracea* var. *gongylodes, B. pekinensis, Camelina sativa, Capsella grandiflora, Conringia orientalis, Diplotaxis viminea*, Erysium × allionii, E. cheiranthoides, Lepidium sativum, Malcolmia flexuosa, M. littorea, M. maritima, Matthiola incana* var. *annua, Nasturtium officinale, Raphanus caudatus, Sisymbrium altissimum*

Cucurbitaceae: *Benincasa hispida, Bryonia dioica, Chayote edulis* (syn.: *Sechium edule*), *Colocynthis vulgaris*, Cucumis sativus, Cucurbita andreana*, C. lagenaria, C. moschata, C. pepo* convar. *clypeata*, C. pepo* convar. *oblonga*, C. pepo* convar. *patissonina* f. *radiata*, C. pepo* convar. *piriformis*, C. pepo* convar. *pomiformis*, C. pepo* var. *aurantiformis*, C. pepo* var. *melopepo, C. pepo* var. *ovifera, C. pepo* var. *subrotunda*, C. pepo* var. *verrucosa*, Cyclanthera explodens*, C. pedata*, Lagenaria siceraria, L. siceraria* var. *cugurda*, Luffa acutangula, L.* sp., *Melothria guadalupensis, M. scabra, Momordica balsamina, M. charantia, Sicana odorifera, Trichosanthes anguina*

Dipsacaceae: *Dipsacus* sp., *Scabiosa atropurpurea, S. japonica*

Euphorbiaceae: *Euphorbia marginata, E. splendens, Ricinus communis*

Fabaceae (Leguminosae, Papilionaceae): *Cajanus indicus, Crotalaria intermedia, C. mucronata, Dolichos lablab, Glycine max, Lathyrus odoratus, Lens culinaris* (syn.: *L. esculenta*), *L. esculenta* (syn.: *L. culinaris*), *Lupinus hartwegii, L.*-Hybrids, *L. polyphyllus, Melilotus albus, M. officinalis, Phaseolus acutifolius* var. *latifolius, P. aureus, P. calcaratus, P. limensis, P.*

vulgaris, Trifolium incarnatum, T. pratense, T. repens, Trigonella foenumgraecum, Vicia faba, V. faba var. *minor, Vigna sesquipedalis, V. unguiculata*

Geraniaceae: *Erodium ciconium*, E. cicutarium, E. gruinum*, E. malacoides*, E. manescavi*, E. moschatum*, Geranium dissectum*, G. sibiricum**

Gramineae (Poaceae): *Euchlaena mexicana, Holcus sorghum, Secale cereale, Triticum aestivum, Zea mays*

Hydrophyllaceae: *Nemophila manziesii, Phacelia tanacetifolia, P. whitlavia*

Iridaceae: *Gladiolus hortulanus, Sparaxis* sp.

Labiatae (Lamiaceae): *Coleus blumei, C. lanugiosus, Majorana* sp., *Marrubium vulgare, Ocimum canum*, O. carnosum* (HORVÁTH—BESEDA 1979), *O. sanctum*, O. selloi, O. viride* (BESEDA—HORVÁTH 1980), *Salvia coccinea, S. patens, Stachys lanata*

Liliaceae: *Allium cepa, Calochortus* sp., *Colchicum autumnale, Fritillaria pudica, Gloriosa rothschildiana, Hyacinthus orientalis, Lilium auratum, L. brownii, L. canadense, L. formosanum, L. harrisii, L. longiflorum* var. *formosum, L. monadelphum, L. regale, L. sargentiae, L. speciosum, L. speciosum* var. *rubrum, L. superbum, L. umbellatum, L. wallacei, Tulipa gesneriana*

Lobeliaceae: *Lobelia erinus, L. gracilis, L. tenuior*

Lythraceae: *Lythrum salicaria*

Malvaceae: *Hibiscus manihot, Lavatera trimestris, Malope trifida, Malva borealis, M, moschata, M. neglecta*, M. pusilla*, M. verticillata**

Marantaceae: *Maranta arundinacea*

Moraceae: *Humulus scandens*

Musaceae: *Ensete glaucum, Musa banksii, M. ensete, M. textilis, M. textilis* × *M. balbisiana, M. Textilis* × *M. Banksii*

Nolanaceae: *Nolana paradoxa* (HORVÁTH 1977, unpublished)

Nyctaginiaceae: *Mirabilis jalapa*

Onagraceae (Oenotheraceae): *Clarkia elegans, Godetiaoena am, Oenothera biennis, O. tetragona*

Orchidaceae: *Miltonia* sp.

Papaveraceae: *Papaver alpinum, P. glaucum, P. orientale, P. rhoeas*

Passifloraceae: *Adenia* sp., *Passiflora alba, P. foetida, P. ligularis, P. suberosa, P. subpeltata, Tacsonia* sp.

Pedaliaceae: *Sesanum indicum*

Phytolaccaceae: *Phytolacca acinosa* (syn.: *P. esculenta*), *P. esculenta* (syn.: *P. acinosa*)

Polemoniaceae: *Cobaea scandens, Gilia capitata, G. liniflora, Phlox drummondii*

Polygonaceae: *Fagopyrum esculentum, Rheum rhaponticum, Rumex crispus*

Portulacaceae: *Portulaca grandiflora*

Primulaceae: *Anagallis arvensis, Primula sinensis, P. veris, P. vulgaris*

Ranunculaceae: *Delphinium cultorum, D. formosum, D.*-Hybrids, *D. nudicaule, D. parryi* var. *maritimum, Ranunculus asiaticus*

Resedaceae: *Reseda odorata*

Rutaceae: *Citrus medica*

Scrophulariaceae: *Asarina barclaiana, Cymbalaria muralis, Erinus alpinus, Linaria bipartita, L. maroccana, Mimulus moschatus, Nemesia strumosa, Paulownia fargesii**, *Pentstemon hartwegii, P.* sp., *Torenia fournieri, Verbascum phoeniceum, Veronica longifolia, Zaluzianskya villosa*

Solanaceae: *Atropa bella-donna, Browallia americana* (syn.: *B. demissa*)*, *B. cordata**, *B. demissa* (syn.: *B. americana*)*, *B. grandiflora**, *B. roezli**, *B. speciosa, B. viscosa**, *Capsicum annuum* cv. *Bogyiszlói vastaghúsú**, *C. annuum* cv. *Cecei édes**, *C. annuum* cv. *Csokros csüngő**, *C. annuum* cv. *Csokros felálló I.**, *C. annuum* cv. *Csokros felálló II.**, *C. annuum* cv. *Hatvani hajtatási**, *C. annuum* cv. *Korai halványzöld**, *C. annuum* cv. *Kovácsházi hajtatási**, *C. annuum* cv. *Magyar kincs**, *C. annuum* cv. *Tétényi hajtatási zöld**, *Datura ceratocaula**, *D. chlorantha* (syn.: *D. humilis*)*, *D. fastuosa* cv. *Alba**, *D. gigantea* (syn.: *D. tatula*)*, *D. godronii* cv. *Minka**, *D. humilis* (syn.: *D. chlorantha*)*, *D. inermis* (syn.: *D. stramonium* f. *inermis*)*, *D. inoxia, D. leichardtii**, *D. metel, D. meteloides, D. rosei**, *D. stramonium* f. *inermis* (syn.: *D. inermis*)*, *D. tatula* (syn.: *D. gigantea*)*, *Hyoscyamus niger, Lycium barbarum* (syn.: *L. halimifolium*)*, *L. carolinianum**, *L. chinense**, *L. europaeum**, *L. flexicaule**, *L. halimifolium* (syn.: *L. barbarum*)*, *L. horridum**, *L. ruthenicum**, *L. turcomanicum**, *Lycopersicon esculentum* cv. *Kecskeméti* 363.*, *L. esculentum* cv. *Kecskeméti konzerv**, *L. esculentum* cv. *Pécs gyöngye**, *Nicandra physaloides, Nicotiana affinis, N. alata, N. bigelovii* var. *quadrivalvis, N. chinensis**, *N. clevelandii, N. glutinosa, N. knightiana**, *N. langsdorffii, N. paniculata, N. quadrivalvis**, *N. repanda, N. rustica, N. sanderae, N. sylvestris, N. tabacum* cv. *Debreceni**, *N. tabacum* cv. *Érdi**, *N. tabacum* cv. *Hevesi**, *N. tabacum* cv. *Kerti**, *N. tabacum* cv. *Szabolcsi**, *N. tabacum* × *N. glutinosa, Petunia atkinsiana**, *P. hybrida* cv. *Rose de Haven amélioré**, *P.*-Hybrids, *P. inflata* (Horváth 1977, unpublished), *P. nyctaginiflora* (Horváth 1977, unpublished), *P. parviflora**, *P. violacea, Physalis alkekengi, P. curassavica* (Horváth—Besada 1980, in preparation), *P. floridana, P. heterophylla, P. heterophylla* var. *nyctaginea, P. ixocarpa**, *P. lagascae, P. peruviana**, *P. peruviana* var. *macrocarpa**, *P. philadelphica**, *P. pruinosa**, *P. rigida, P.* sp., *P. subglabrata, P. viscosa**, *Salpiglossis sinuata, Schizanthus wisetonensis, Solanum acaule, S. antipoviczii, S. atropurpureum, S. aviculare, S. berthaultii, S. boliviense, S. brachycarpum, S. bukasovii, S. canadense, S. capsicastrum, S. caribaeum, S. caripense, S. carolinense, S. catarthum, S. chacoense, S. chomatophilum, S. demissum, S. demissum* × *S. tuberosum* 'A6'-Hybrid*, *S. depexum, S. famatinae, S. fendleri, S. gibberulosum, S. gigantophyllum, S. gourlayi, S. hjertingii, S. hougasii, S. integrifolium, S. jamesii, S. kesselbrenneri, S. kurtzianum, S. laciniatum, S. longipedicellatum, S. microdontum, S. miniatum, S. nigrum* var. *guineense, S. nodiflorum, S. oxycarpum, S. pampasense, S. phureja, S. pinnatisectum, S. polyadenium, S. raphanifolium, S. rostratum**, *S. rybinii, S. sanctae-rosae, S. schreiteri, S. sogarandinum, S. sparsipilum, S. spegazzinii, S. stenotomum, S. stoloniferum, S. subtilius, S. tarijense, S. torvum, S. triflorum, S. tuberosum* ssp. *aemulans, S. tuberosum* ssp. *andigenum, S. vernei, S. villosum*

Umbelliferae (Apiaceae): *Ammi majus**, *A. visnaga**, *Anthriscus cerefolium, Antirrhinum majus, Eryngium aquaticum, Foeniculum vulgare*

Verbenaceae: *Verbena-Hybrids*

Violaceae: *Viola cornuta*

Plants resistant against infection with the cucumber mosaic virus

Among the tested plants 402 species of 244 genera and 71 families (Table 2) were reported once or more to be resistant to infection with this virus. Due to the improvement of inoculation techniques, 131 of these species (designated by a question mark in the list of tested plants) proved to be susceptible. So the actual number of resistant plants should be 271 species. In the following the total number of tested plants resistant to cucumber mosaic virus is listed:

Acanthaceae: ? *Ruellia tuberosa, Thunbergia alata*

Aizoaceae: *Aptenia cordifolia**

Amaranthaceae: *Amaranthus cruentus,* ? *A. dubius, A. hybridus,* ? *A. retroflexus,* ? *A. spinosus,* ? *Celosia argentea,* ? *Gomphrena globosa*

Amaryllidaceae: *Amaryllis (Hippeastrum) vittatum, Hymenocallis* spp., ? *Narcissus tazetta, Vallota purpurea*

Apocynaceae: ? *Catharanthus roseus*

Araceae: *Philodendron* spp., *Xanthosoma* spp.

Balsaminaceae: ? *Impatiens balsamina*

Begoniaceae: ? *Begonia semperflorens*

Bignoniaceae: *Bignonia capreolata, Incarvillea delavayi*

Boraginaceae: *Anchusa azurea, A. officinalis, Heliotropium peruvianum,* ? *Myosotis scorpioides*

Bromeliaceae: *Ananas sativus, Dendropogon usneoides* (syn.: *Tillandsia usneoides*), *Tillandsia fasciculata, T. usneoides* (syn.: *Dendropogon usneoides*)

Campanulaceae: ? *Campanula medium, Platycodon grandiflorum*

Cannaceae: *Canna edulis, C. glauca*

Capparidaceae: ? *Cleome spinosa*

Caricaceae: *Carica papaya*

Caryophyllaceae: *Alsine media, Cerastium tomentosum,* ? *Dianthus caryophyllus, D. plumarius, Gypsophila paniculata*

Chenopodiaceae: *Beta vulgaris,* ? *B. vulgaris* var. *cicla,* ? *Chenopodium album, C. botrys, Kochia scoparia,* ? *Spinacia oleracea*

Cistaceae: *Helianthemum* sp.

Commelinaceae: *Commelina coelestis,* ? *C. nudiflora,* ? *C.* sp., *Tinantia erecta* (syn.: *T. fugax*)*, *T. fugax* (syn.: *T. erecta*)*

Compositae (Asteraceae): *Achillea millefolium,* ? *Ageratum houstonianum, Ambrosia artemisiifolia, Aster novae-angliae, A.* spp., *Bidens cynapiifolia, B. leucantha, B. pilosa,* ? *Calendula officinalis,* ? *Callistephus chinensis,* ? *Centaurea cyanus,* ? *Chrysanthemum carinatum, C. coccineum,* ? *C. leucanthemum,* ? *C. morifolium,* ? *C. parthenium,* ? *Cichorium endivia,* ? *C. intybus, Coreopsis drummondii,* ? *C. tinctoria,* ? *Cosmos bipinnatus,* ? *Crassina elegans,* ? *Dahlia pinnata,* ? *D. variabilis, Emilia sonchifolia, Erigeron* spp., *Gaillardia pulchella,*

* Denotes new resistant plants against cucumber mosaic virus (Horváth 1976, 1979b)

? *Helichrysum bracteatum*, ? *Lactuca sativa*, *L. sativa* var. *capitata*, *L. sativa* var. *crispa*, *L. sativa* var. *longifolia*, *Parthenium argentatum*, *Senecio cruentus*, ? *Sonchus oleraceus*, *Tragopogon porrifolius*, ? *Zinnia elegans*

Convolvulaceae: ? *Convolvulus tricolor*, ? *Ipomoea batatas*, *I. quinquefolia*, *I. setosa*, ? *I.* sp., *Cuscuta californica*, ? *C. campestris*, *C. sandwichiana*, *C. subinclusa*

Crassulaceae: *Sedum acre*

Cruciferae (Brassicaceae): *Brassica alba* (syn.: *B. hirta*), ? *B. campestris* var. *napobrassica*, *B. hirta* (syn.: *B. alba*), ? *B. napus*, ? *B. nigra*, *B. oleracea*, ? *B. oleracea* var. *acephala*, ? *B. oleracea* var. *botrytis*, ? *B. oleracea* var. *capitata*, *B. oleracea* var. *caulorapa*, ? *B. oleracea* var. *gemmifera*, ? *B. oleracea* var. *gongylodes*, *B. oleracea* var. *viridis*, ? *B. pekinensis*, *B. rapa*, *B. rapa* var. *depressa*, ? *Cheiranthus cheiri*, *Crambe abyssinica**, *C. armena**, *C. cordifolia**, *C. hispanica**, ? *C. maritima**, *C. orientalis**, *C. tataria**, ? *Iberis umbellata*, *Lepidium virginicum*, ? *Lobularia maritima*, ? *Matthiola incana*, ? *Raphanus sativus*

Cucurbitaceae: *Citrullus citrullus*, *C. vulgaris*, *C. vulgaris* var. *fistulosus*, ? *Cucumis melo*, *C. myriocarpus**, ? *C. sativus*, ? *Cucurbita lagenaria*, *Ecballium elaterium*, *Lagenaria leucantha* (syn.: *L. siceraria*), *L. siceraria* (syn.: *L. leucantha*), *Luffa aegyptiaca* (syn.: *L. cylindrica*), *L. cylindrica* (syn.: *L. aegyptiaca*), ? *Momordica charantia*, *Sechium edule*

Cyperaceae: *Cyperus compressus*, *C. esculentus*

Dioscoreaceae: *Dioscorea alata*, *D. bulbifera*

Ericaceae: *Leiophyllum buxifolium**

Euphorbiaceae: *Adenorhopium gossypifolium* (syn.: *Jatropa gossypifolium*), *Codiaeum variegatum*, ? *Euphorbia marginata*, *E. pulcherrima*, *Jatropa gossypifolium* (syn.: *Adenorhopium gossypifolium*), *Manihot esculenta* (syn.: *M. ultissima*), *M. ultissima* (syn.: *M. esculenta*), ? *Ricinus communis*

Fabaceae (Leguminosae, Papilionaceae): *Arachis hypogaea*, *Canavalia ensiformis*, *C. gladiata*, *Cassia tora*, *Chapmannia floridana*, ? *Cicer arietinum*, *Clitoria ternatea*, *Crotalaria spectabilis*, *C.* spp., *Desmodium incanum*, ? *Dolichos lablab*, *Glycine hispida*, ? *G. max*, ? *Lathyrus odoratus*, *Lens esculenta*, *Lupinus albus*, *L. hirsutus*, ? *L. mutabilis*, ? *L. polyphyllus*, ? *Medicago sativa*, *Melilotus alba*, ? *M. officinalis*, ? *Phaseolus calcaratus*, ? *P. limensis*, ? *P. lunatus*, ? *P. vulgaris*, *P. vulgaris* cv. *Red Kidney**, ? *Pisum sativum*, ? *Trifolium hybridum*, ? *T. incarnatum*, ? *T. pratense*, ? *T. repens*, ? *Vicia faba*, *V. sativa*, *V. villosa*, ? *Vigna sisnensis*, ? *V. unguiculata*

Geraniaceae: *Geranium cristatum**, *G. columbianum**, *G. lucidum**, *G. molle**, *G. pratense**, *G. pusillum**, *G. pyrenaicum**, *G. robertianum**, ? *G.rotundifolium**, *Pelargonium zonale*

Gesneriaceae: *Sinningia speciosa*

Gramineae (Poaceae): *Avena sativa*, *Cynodon dactylon*, ? *Holcus sorghum*, *Hordeum vulgare*, *Oryza sativa*, *Panicum barbinode*, *Poa pratensis*, *Saccharum officinarum*, *Sorghum vulgare*, *Stenotaphrum secundatum*, *Tricholaena repens* (syn.: *T. rosea*), *T. rosea* (syn.: *T. repens*), ? *Triticum aestivum*, ? *Zea mays*

Hydrophyllaceae: *Nemophila insignis*, *Phycelia campanularia*

Iridaceae: *Belamcanda chinensis*, *Freesia hybrida*, *Gladiolus lemoinei*, *Iris filifolia*, ? *I. germanica*, *I. pallida*, *I. versicolor*, *Moraea iridioides*, *Tigridia pavonia*, *Tritonia crocata*

Labiatae (Lamiaceae): ? *Coleus lanuginosus*, ? *Lamium amplexicaule*, *Leonotis nepetaefolia*, ? *Mentha spicata*, *Physostegia virginiana*, ? *Salvia splendens*

Liliaceae: *Agapanthus africanus*, ? *Allium cepa*, *A. cernuum*, *A. odorum*, *A. speciosum*, *Aloë* spp., *Asparagus asparagoides*, ? *A. officinalis*, *A. plumosus*, *A. sprengeri*, *Asphodeline lutea*, *Brodiaea uniflora*, *Camassia leichtlinii*, *Convallaria majalis*, *Dracaena sanderiana*, *Erythronium* spp., *Galtonia candicans*, *Haworthia altilinea*, *Hemerocallis flava*, *Hosta plantaginea*, *Kniphofia tucki*, *K. uvaria*, *Lilium davidi*, *L. hansonii*, *L. henryi*, *L. humboldtii*, *L. martagon* var. *album*×*L. hansonii*, *L. nepalense*, *L. pardalinum*, *L. pardalinum* var. *giganteum*, *L. parryi*, *L. parvum*, ? *L. sargentiae*, ? *L. superbum*, *Muscari polyanthum*, *Nothoscordum fragrans*, *Ophiopogon jaburan*, *Ornithogalum thyrsoides*, *Sansevieria thrysiflora*, *S. zeylanica*, *Smilacina racemosa*, *Smilax* spp., *Tricyrtis hirta*, *Trillium* spp., ? *Tulipa gesneriana*, *Uvularia sessilifolia*, *Yucca baccata*, *Y. flaccida*, *Y. gloriosa*

Linaceae: *Linum* sp.

Lobeliaceae: *Isotoma longiflora*, ? *Lobelia erinus*

Malvaceae: *Abelmoschus esculentus*, *Althaea rosea*, *Gossypium hirsutum*, *G.* spp., ? *Hibiscus esculentus*, *H. rosa-sinensis*, *Malva rotundifolia*, *Modiola virginica*, *Sida carpinifolia*

Musaceae: *Musa balbisiana*, ? *M. banksii*, *M. cavendishii*, *M. ornatus*, *M. paradisiaca*, *M. paradisiaca* subsp. *sapientum*, *M. paradisiaca* subsp. *sapientum* var. *cinerea*, *M. paradisiaca* subsp. *sapientum* var. *lacatan*, *M. paradisiaca* subsp. *sapientum* var. *suaveolens*, *M. sapientum* var. *compressa*, ? *M. textilis*, ? *M. textilis*×*M. balbisiana*

Myrtaceae: *Psidium guajava*

Nyctaginiaceae: ? *Mirabilis jalapa*

Onagraceae (Oenotheraceae): ? *Clarkia elegans*, *Jussiaea angustifolia*

Oxalidaceae: *Ionoxallis violacea*, *Xanthoxalis corniculata*

Papaveraceae: *Eschscholzia californiaca*, ? *Papaver orientale*, ? *P. rhoeas*, *P. somniferum*

Phytolaccaceae: *Phytolacca decandra*, *Rivina humilis aurantica*

Plantaginaceae: *Plantago major*, *P.* spp.

Plumbaginaceae: *Limonium latifolium*, *L. sinuatum*, *Statice armeria*

Polygonaceae: *Eriogonum fasciculatum*, *Polygonum aviculare*, *Polypodium vulgare*, *Rumex occidentalis*

Polypodiaceae: *Adianthum capillus-veneris*

Pontederiaceae: *Piaropus crassipes* (syn.: *Eichhornia crassipes*), *Pontederia cordata*

Portulacaceae: ? *Portulaca grandiflora*

Primulaceae: ? *Primula vulgaris*

Proteaceae: *Grevillea robusta*

Ranunculaceae: ? *Aquilegia caerulea*, ? *Delphinium cultorum*, *Nigella damascena*

Resedacea: ? *Reseda odorata*

Rosaceae: *Geum chiloense*, *Rosa dilecta*, *R. laevigata*

Rubiaceae: *Asperula odorata*

Rutaceae: *Citrus aurantium*, *Citrus grandis*, *Citrus nobilis*, *C. sinensis*, *C.* spp.

Sapindaceae: *Cardiospermum halicacabum*

Saxifragaceae: *Heuchera sanguinea*, *Saxifraga* sp.

Scrophulariaceae: *Antirrhinum majus, Digitalis purpurea, Gerardia divaricata, Linaria canadensis, L. floridana, Pentstemon alpinus*, P. attenuatus*, P. calycosus*, P. cardinalis*, P. hirsutus*, P. laevigatus*, P. ovatus*, P. whippleanus**

Solanaceae: ? *Capsicum frutescens, C. frutescens* var. *cerasiforme, Datura* spp., ? *D. stramonium,* ? *Lycopersicon esculentum, L. lycopersicon,* ? *Nicotiana glauca,* ? *N. glutinosa,* ? *N. rustica,* ? *N. tabacum,* ? *Petunia hybrida,* ? *P. violacea,* ? *Physalis angulata,* ? *Salpiglossis sinuata, Schizanthus pinnatus,* ? *Solanum caribaeum,* ? *S. dulcamara,* ? *S. melongena, S. pseudocapsicum,* ? *S. tuberosum*

Thymeleaceae: *Daphne cneorum*

Tropaeolaceae: ? *Tropaeolum majus*

Typhaceae: *Typha angustifolia*

Umbelliferae (Apiaceae): *Apium graveolens,* ? *Apium graveolens* var. *dulce, Celeri graveolens, Ferula communis, Trachymene caerulea*

Valerianaceae: ? *Valeriana officinalis*

Verbenaceae: *Clerodendron fragans, Lantana camara, L. sellowiana, Valerianoides yamaicensis, Verbena hybrida, V. venosa*

Violaceae: *Viola floridana,* ? *V. odorata, V. primulifolia,* ? *V. tricolor*

Zingiberaceae: *Hedychium coronarium*

Acknowledgements

Grateful thanks are due to Dr. P. Hanelt (Gatersleben, GDR) for his help in forwarding information on the taxonomic problems which arose in the present work.

*

Prepared at the University of Agricultural Sciences, Institute for Plant Protection, Keszthely. J. Horváth

References

Besada, W.—Horváth, J. (1980): Újabb adatok a *Labiatae* (*Lamiaceae*) családba tartozó növények vírusfogékonyságáról. 3. *Ocimum selloi* Benth. és *Ocimum viride* Willd. (New data concerning the susceptibility of members of the family *Labiatae* [*Lamiaceae*] to plant viruses. 3. *Ocimum selloi* Benth. and *Ocimum viride* Willd.). Növénytermelés, **29,** in press.

Costa, A. S.—Duffus, J. E. (1958): Observations on lettuce mosaic virus in California. Plant Dis. Rep., **42,** 583—586.

Edwardson, J. R. (1974): Host ranges of viruses in the PVY-group. Florida Agricultural Experiment Stat., Monograph Ser., **5,** 1—225.

Horváth, J. (1976): Vírus-gazdanövénykörök és vírusdifferenciálás (Host ranges of viruses and virus separation, D. Sc. Thesis). Akad. Dokt. Ért., Budapest—Keszthely, 607.

Horváth, J. (1979a): New artificial hosts and non-hosts of plant viruses and their role in the identification and separation of viruses. VIII. Potyvirus group (Subdivision-II): Bean yellow mosaic virus and lettuce mosaic virus. Acta Phytopath. Hung., **14,** 147—155.

Horváth, J. (1979b): New artificial hosts and non-hosts of plant viruses and their role in the identification and separation of viruses. X. Cucumovirus group: Cucumber mosaic virus. Acta Phytopath. Hung., **14,** 285—295.

Horváth, J. (1980): Viruses of lettuce. I. Natural occurrence — A review. Acta Agr. Hung., **29,** 62—67.

Horváth, J.—Beseda, W. (1979): Újabb adatok a *Labiatae* (*Lamiaceae*) családba tartozó növények vírusfogékonyságáról. 2. *Ocimum sanctum* L. és *Ocimum carnosum* Link. et

Otto (New data concerning the susceptibility of members of the family *Labiatae* [Lamiaceae] to plant viruses. 1. *Ocimum sanctum* L. and *Ocinum carnosum* Link. et Otto). Növénytermelés, **28,** 507—510.

Jagger, I. C. (1921): A transmissible mosaic disease of lettuce. J. Agr. Res., **20,** 737—740.

Joshi, R. D.—Dubey, L. N. (1976): Some weed reservoirs of cucumber mosaic virus in Gorakhpur and adjacent areas. Indian Phytopath., **28,** 568.

Kemper, A. (1962): Zum Auftreten von Salatmosaikvirus an Salat (*Lactuca sativa* L.) und an Kreuzkraut (*Senecio vulgaris* L.). Z. PflKrankheiten, **69,** 653—663.

Klinkowski, M.—Uschdraweit, H. A. (1968): Gemüsepflanzen. *In:* Klinkowski, M. (ed.), Pflanzliche Virologie. Band II. Die Virosen des europäischen Raumes. Teil 2., Akademie Verlag, Berlin, 1—75.

Kovachevsky, I. (1965): Die Gurkenmosaikvirose in Bulgarien. Verlag Bulg. Akad. Wiss., Sofia, 80.

Kovachevsky, I. (1976): New cucumber mosaic virus (CMV) host plants in Bulgaria. Plant Prot. Sci., **4,** 5—10.

Lisa, V.—Lovisolo, O. (1976): A mosaic disease of *Primula obconica* caused by a potyvirus. Acta Horticulture, **59,** 167—173.

Migliori, A. — Quiot, J. B. — Leclant, F. — Marchoux, G. — Coléno, A. (1977): First observations in Guadeloupe about cucumber mosaic virus and watermelon mosaic virus epidemiology. Ann. Phytopathol., **9,** 123—139.

Nitzany, F. E.—Cohen, S. (1960): Lettuce mosaic virus in Israel. Ktavim, **10,** 231—232.

Polák, Z. (1964): *Campanula rapunculoides* L. — a natural source of cucumber mosaic virus. Preslia, **36,** 306.

Price, W. C. (1940): Comparative host ranges of six plant viruses. Amer. J. Bot., **27,** 530—541.

Provvidenti, R.—Schroeder, W. T. (1972): Natural infection of *Spinacia oleracea* by lettuce mosaic virus. Plant Dis. Rep., **56,** 281—284.

Provvidente, R. (1973): Occurrence of lettuce mosaic virus in *Pisum sativum*. Plant Dis. Rep., **57,** 688—690.

Purcifull, D. E.—Zitter, T. A. (1971): Virus diseases affecting lettuce and endive in Florida. Florida State Hort. Soc., **84,** 165—168.

Purivirojkul, W.—Poehlman, J. M. (1977): Injury in mungbean from natural infection with cucumber mosaic virus. Crop. Sci., **17,** 654—656.

Ragozzino, A.—Caia, R.—Xafis, C. (1971): I virus patogeni della lattuga in Campania — Nota I. Riv. Ortoflorofrutticolt. Ital., **4,** 356—376.

Ryder, E. J. (1970): Screening for resistance to lettuce mosaic virus. Hort. Sci., **5,** 47—48.

Salamon, P. (1979): Az uborka mozaik vírus újabb természetes gazdái Magyarországon (New natural hosts of the cucumber mosaic virus in Hungary). MTA Agrártud. Oszt. Közl., (in press).

Schmelzer, K. (1962a): Untersuchungen an Viren der Zier- und Wildgehölze. 1. Mitteilung. Virosen an *Viburnum* und *Ribes*. Phytopath. Z., **46,** 17—52.

Schmelzer, K. (1962b): Untersuchungen an Viren der Zier- und Wildgehölze. 2. Mitteilung. Virosen an *Forsythia*, *Lonicera*, *Ligustrum* und *Laburnum*. Phytopath. Z., **46,** 105—138.

Schmelzer, K. (1962c): Untersuchungen an Viren der Zier- und Wildgehölze. 3. Mitteilung. Virosen an *Robinia*, *Caryopteris*, *Ptelea* und andere Gattungen. Phytopath. Z., **46,** 235—268.

Schmelzer, K. (1962d): Untersuchungen an Viren der Zier- und Wildgehölze. 4. Mitteilung. Versuche zur Differenzierung und Identifizierung der Ringfleckenviren. Phytopath. Z., **46,** 315—342.

Schmelzer, K. (1970): Untersuchungen an Viren der Zier- und Wildgehölze. 7. Mitteilung. Weitere Befunde an *Buddleja*, *Viburnum*, *Caryopteris* und *Philadelphus* sowie Viren an *Leycesteria*, *Chionanthus*, *Ribes*, *Hydrangea*, *Syringa*, *Spiraea* und *Catalpa*. Phytopath. Z., **67,** 285—326.

Schmelzer, K. (1974): Untersuchungen an Viren der Zier- und Wildgehölze. 8. Mitt. Neue Befunde an *Forsythia*, *Hydrangea* und *Philadelphus* sowie Viren und Virosen an *Rhamnus*, *Centaurea*, *Galvezia*, *Cistus*, *Forestiera*, *Abeliophyllum*, *Celastrus*, *Staphylea* und *Crambe*. Zbl. Bakt. Abt., II. **129,** 139—168.

Schmelzer, K.—Schmidt, H. E. (1968): Untersuchungen an Viren der Zier- und Wildgehölze. 6. Mitteilung. Ergänzende Befunde an *Caryopteris* sowie Virosen an *Philadelphus*, *Aristolochia*, *Buddleja*, *Lycium* und *Aesculus*. Phytopath. Z., **62,** 105—126.

Schmelzer, K.—Wolf, P. (1971): Wirtspflanzen der Viren und Virosen Europas. Johann Ambrosius Barth, Leipzig, 262.

Schmelzer, K.—Wolf, P. (1977): Wirtspflanzen und ihre Viren, Virosen und Mykoplasmosen.

In: KLINKOWSKI, M. et al., Pflanzliche Virologie. Registerband. Verzeichnisse und Übersichten zu den Virosen in Europa. Akademie Verlag, Berlin, 53–189.
SCHMELZER, K.–WOLF, P.–GIPPERT, R. (1977): Gemüsepflanzen. *In:* KLINKOWSKI, M. et al.: Pflanzliche Virologie. Band 3. Die Virosen an Gemüsepflanzen, Obstgewächsen und Weinreben in Europa. Akademie Verlag, Berlin, 1–138.
SHUKLA, D. D.–SCHMELZER, K. (1970): Studies on viruses and virus diseases of cruciferous plants. I. Viruses in some ornamentals. Acta Phytopath. Hung., **5**, 137–144.
SHUKLA, D. D.–SCHMELZER, K. (1973): Studies on viruses and virus diseases of cruciferous plants. XIV. Cucumber mosaic virus in ornamental and wild species. Acta Phytopath. Hung., **8**, 149–155.
SHUKLA, D. D.–SCHMELZER, K. (1975): Studies on viruses and virus diseases of cruciferous plants. XIX. Analysis of the results obtained with ornamental and wild species. Acta Phytopath. Hung., **10**, 217–229.
THORNBERRY, H. H. (1966): Index of plant virus diseases. Agr. Handbook No. 307. Agr. Res. Serv., U.S. Dept. Agr. Washington, 446.
TOMLINSON, J. A. (1964): Purification and properties of lettuce mosaic virus. Ann. Appl. Biol., **53**, 95–102.
TOMLINSON, J. A. (1970): Lettuce mosaic virus. CMI/AAB. Descriptions of plant viruses. No. 9.
ULLRICH, J. (1954): Untersuchungen über Salatmosaik. NachrBl. Dtsch. PflSchutzd., **6**, 182–184.
WILKINSON, R. E.–HIRSCH, U. (1952): Local lesion hosts for the lettuce mosaic virus. Phytopathology, **42**, 478.
ZINK, F. W.–DUFFUS, J. E.–KIMBLE, K. A. (1973): Relationship of a non-lethal reaction to a virulent isolate of lettuce mosaic virus and turnip mosaic virus susceptibility in lettuce. J. Amer. Soc. Hort. Sci., **98**, 41–45.

INORGANIC AND ORGANIC N TRANSPORT OF XYLEM SAP IN ROOTS OF DECAPITATED MAIZE HYBRIDS

By studying the absorbing and assimilating activities of the root system of maize under the same external conditions and at identical stages of plant development information can be obtained on various hereditary features of the nutrient synthesis in inbred lines and hybrids with different genotypes (CLARKSON 1976, AMOS—SCHOLL 1977, PINTÉR *et al.* 1977a, SZUNDY 1978).

The analysis of xylem sap, used by many researchers (ANDERSON *et al.* 1970, MENGEL—SIMIC 1973, UKHINA 1976, KARMOKER—VAN STEVENINCK 1978, VON SCHRADER—PRZEMECK 1978), proved suitable for demonstrating the inorganic N-forms taken up by the root system and for studying how they are transported and transformed into organic compounds.

In Hungary the exudation of xylem sap from the root and the transformation of N compounds were studied by POTAPOV—DÉZSI (1954) in wheat and by POTAPOV—CSEH (1955) in decapitated maize. Collecting sap separately twice a day they found that at flowering time the exudation of xylem sap lasted for 9 days after the decapitation, while the amount of sap and the nutrient concentration gradually decreased.

When studying the xylem sap of decapitated maize DÉVAY—GÁSPÁR (1958) clarified the nutrition biology relations of the main and lateral shoots using labelled nutrients.

LÁNG—GÁTI (1958) collected xylem sap and leaf samples at 9 different development stages of maize. According to the results of their investigations, changes in the quantity and composition of the xylem sap may predict how the dry matter weight and chemical composition of the leaves will develop. The authors examined the same local variety under different ecological and growing conditions.

According to PÁLFI (1966), as a consequence of dense sowing there may be sharp competition between maize plants with fully developed root systems as to the amount of xylem sap accumulated in 12 hours and the concentration of nutrients. This phenomenon may be even more apparent between different varieties or hybrids.

Spacing causes changes not only in the morphology and metabolism of the root system, but also, of course, in the aboveground organs and the yield, as pointed out by DABIAN (1973), NÉMETH—PINTÉR (1975), BONAPARTE (1975) and SZUNDY (1978).

In the present experiment the xylem sap transported by detached roots was used to identify the major groups of nitrogen compounds fixed in inorganic and organic forms, and to establish the total amount of nitrogen in the sap.

The intensity of synthesis in the root system is indicated by the extent to which the inorganic N compounds are transformed into organic forms (TENDILLE *et al.* 1972, MENGEL—SIMIC 1973, UKHINA 1976, KARMOKER—VAN STEVENINCK 1978, PINTÉR *et al.* 1978b). In the present experiment the synthesizing activity of the root system was studied by means of quantitative determination of free amino acids and proteins in xylem sap accumulated in 12 hours.

The investigations were aimed primarily at comparing the synthesis and nitrogen-transport in the root system of two maize hybrids with different genotypes under identical growing conditions and at the same stage of plant development.

The collection and analysis of xylem sap from detached roots were carried out with two maize hybrids with different genotypes, namely:

1. Sze DC 289 (FAO 289) (GK1 $\times$ GK3) (GK2 $\times$ W 37A),
2. K SC 360 (FAO 360) (A90 $\times$ 153R)

The experimental plants were grown on an 80 cm deep humic, highly calcareous meadow chernozem soil (sandy loam). The plots were given 400 kg/ha mixed fertilizer at a ratio of 2 : 1 : 1 (N : P_2O_5 : K_2O). The land had been sown exclusively to maize for 8 years.

The two hybrids were sown at different dates so as to achieve a coincidence in the final phases of shooting. The plant density was 6.0/m^2 (plants spaced at 70 $\times$ 23.5 cm in alternating rows).

Xylem sap was collected twice at the end of shooting:

1. at Kuperman's development stage VII of male flowering (two weeks before female flowering);
2. at Kuperman's development stage VIII of male flowering (one week before female flowering).

On hot summer days the xylem sap could easily begin to decompose during the 12-hour collecting period, so night sap was analysed. No essential difference in the quantity and composition of N-compounds in day and night saps collected from maize was found by POTAPOV—CSEH (1955). The xylem sap was collected for 12 hours from 7 p.m. to 7 a.m. next morning.

In order to prevent the protoplasm of the cells destroyed by the fine saw used for cutting from disturbing the determination of the protein the cut surface was smoothed down with a razor blade, then washed several times with sterile distilled water.

To prevent the multiplication of microbes ethanol and 50 mg/lit. streptomycin were added to the sap receivers, as suggested by GREENWAY (1970). The volume of sap obtained from 15 plants per hybrid was measured and used to calculate the volume for 10. The concentrations refer to 1 ml pure xylem sap.

The nitrate N concentrations of root exudates were determined by the phenol-disulphic acid method according to LANGE (1961). The NH_4-N was determined with Nessler's reagent against a standard series.

The qualitative determination of free amino acids was carried out using ascending one- and two-dimensional paper or thin layer chromatography. The solvent was a mixture of butanol-acetic acid-water (3 : 1 : 1), and in the second dimension a phenol-water (4 : 1) mixture was used. The staining developer was 0.5% acetone ninhydrine, and copper nitrate solution was used to fix the colours. During the developing process cadmium-ninhydrine, a compound which immediately fixes and provides an easily eluable stain, was also used.

The method used to determine the total eluation amino acids has already been published (Pálfi 1970, Pálfi *et al.* 1973). Asparagine was measured against a standard (Pálfi *et al.* 1973, 1977).

For the protein determination the turbidimetric method of Colowick—Kaplan (1957) was employed, with 3 kinds of reagent, each of them in 4 replications; the results were averaged. The concentrations of the chemicals producing turbidity were raised fourfold compared to those given in the description of the method: 1. 20% trichloro-acetic acid; 2. 10% sulphosalicilic acid; 3. 4% potassium ferrocyanide + 0.3 ml acetic acid. 1 ml reagent was added to 4 ml xylem sap.

The NO_3-N, NH_4-N, total amino acid and total protein contents were determined by spectrophotometry, each sample in 4 replications. If the error exceeded $\pm 5\%$ of the average result, the whole measurement was repeated.

The concentrations of free amino acids and of the nitrogen in TCA-precipitable proteins were determined by spectrophotometry against a standard NH_4Cl series after 24 hours of destruction with a sulphuric acid-perchloric acid mixture at 300°C, followed by neutralization, dilution as required and nesslerization.

Table 1 shows that the quantities of xylem sap collected in 12 hours from the 10 decapitated roots (No. 1) were not very large in any of the hybrids compared to the results obtained with the local varieties (Potapov—Cseh 1955, Dévay—Gáspár 1958, Láng—Gáti 1958, Pálfi 1966).

Table 1

Total amount of xylem sap collected in 12 hours from 10 decapitated roots of two maize hybrids, the inorganic N concentration and N output (expressed as nitrogen), and the free amino acid and amide concentration in μg/ml. "Output" means the total amount of xylem sap exudated in 12 hours by the 10 decapitated roots multiplied by the N-content of inorganic, or the N-concentration of organic compounds (in mg)

Sap amounts (ml), concentrations (μg/ml) and outputs (mg)	Sap collection			
	No. 1		No. 2	
	SzeDC 289	KSC 360	SzeDC 289	KSC 360
1. Amount of sap collected in 12 hours from 10 roots; ml	150	50	102	47
2. Nitrate-N concentration converted to N; μg/ml	197	310	235	245
3. Nitrate-N output from 10 roots; mg	29.6	15.5	24.0	11.5
4. NH_4-N concentration converted to N; μg/ml	39	85	55	68
5. NH_4-N output from 10 roots; mg	5.9	4.3	5.6	3.2
6. Total concentration of N in inorganic compounds; μg/ml	236	395	290	313
7. Total N output of inorganic compounds; mg	35.5	19.8	29.6	14.7
8. Total concentration of free amino acids; μg/ml	902	760	659	1094
9. Glutamine concentration; μg/ml	120	30	160	130
10. Asparagine concentration; μg/ml	200	40	230	150

The analytical results are averages of 4 replications; deviations from these (errors) are below $\pm 5\%$ of the average results.

The difference between the two hybrids in the quantity of sap transported within the same length of time was as much as 300 and 200%. Apart from the root pressure the major determining factor of the water absorbing and transporting capacities in whole, i.e. intact, plants is transpiration. Lower root pressure may be compensated by a higher intensity of transpiration.

According to MOZHAEVA *et al.* (1978) the root pressure that produces the xylem sap consists of osmotic and non-osmotic components. The results of these authors suggest that the level of water uptake by the root system depends primarily on the size of the non-osmotic, active, energetic component, which is related to the carbohydrate reserves. Thus, the intensity of water absorption is closely related not only to the water content of the soil but also to the biological, hereditary properties of the plants (CLARKSON 1976, AMOS—SCHOLL 1977, KARMOKER—VAN STEVENINCK 1978, PINTÉR *et al.* 1978b, VON SCHRADER—PRZEMECK 1978).

According to the data in Table 1 the nitrate-N concentrations are considerable in both hybrids (No. 2), while the NH_4-N concentrations only amount to 1/3 and 1/4, respectively, of the nitrate concentrations (see 2 and 4 in Table 1). Considering that only traces of N bound as nitrite (NO_2-N) were found in the sap, the sum of the concentrations of these two inorganic N-forms also represents the total amount of inorganic N. According to the data on xylem sap collected on two occasions the sum of the concentrations of inorganic N-forms tends to vary with the hybrids. Exact, comparable results are only obtained when the concentrations are multiplied by the total amount of sap collected from the 10 decapitated roots in 12 hours. The total inorganic N output of the transported saps can then be determined.

From point 7 in Table 1 it can be established that on both occasions when sap was collected the hybrid Sze DC 289 transported considerably larger quantities of total inorganic N than the hybrid K SC 360 (the differences being 80 and 100%, respectively !). And although the total concentration of the inorganic N-forms (point 6) in K SC 360 was higher than in Sze DC 289 on both occasions, it could not compensate for the very great differences in the amount of xylem sap.

When studying the forms of nitrogen fixed in organic compounds the first step was the qualitative determination of free amino acids in the xylem sap. No qualitative differences were found either in the free amino acid composition of the two hybrids, or between the results of the two xylem sap collections. The dominant role of amino acid-amides, i.e. of asparagine and glutamine, is generally typical of the composition. To characterize the composition a two-dimensional chromatogram developed from xylem sap No. 1 of the hybrid Sze DC 289 is presented (Fig. 1).

Figure 1 shows that generally all the protein-forming amino acids are found in the xylem sap. Tryptophane and phenylalanine disintegrate during this method of development, so they were determined separately. Cystine and cysteine, as well as valine and methionine appear in a single, complex spot. γ-amino-butyric acid, an important component in the transamination of plants, cannot be found in the xylem sap of the hybrids. In the green aboveground parts of the plants this amino acid can be found in a fairly high concentration, especially when there is a water deficit (PÁLFI 1969, PÁLFI—JUHÁSZ 1971, PINTÉR *et al.* 1977a).

From Table 1 it can be established that the total free amino acid and amide concentrations of the xylem sap are significant in both hybrids (points 8, 9 and 10). The highest concentration of all was measured in hybrid K SC 360, on the second occasion of xylem sap collecting (point 8). It can also be seen that in the first sap sample from Sze DC 289 the total concentration of amides exceeded 1/3 of the total amino acids, while in the second sample it was more than half. A similar excess of amides in xylem sap was found earlier in maize, wheat and rice (PÁLFI 1966). The physiological role and importance of amides in exudates of decapitated roots have been mentioned by other authors (MENGEL—SIMIC 1973, IZMAYLOV *et al.* 1973, PINTÉR *et al.* 1977a, VON SCHRADER—PRZEMECK (1978). In addition, the con-

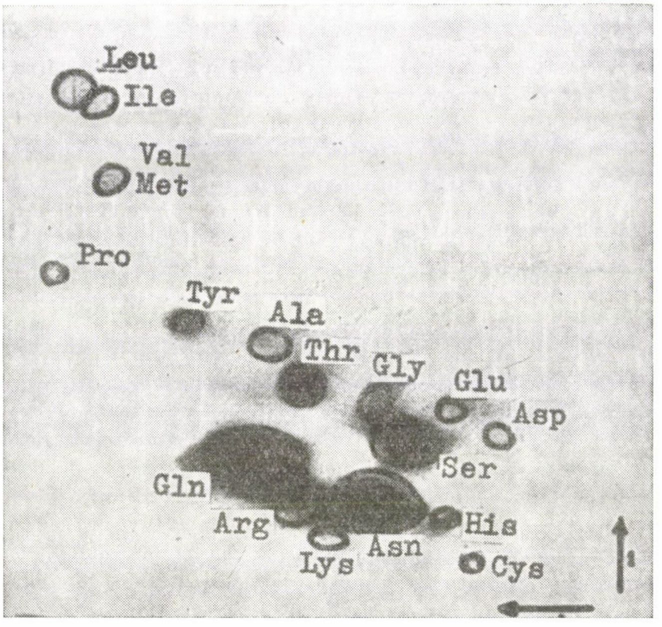


Fig. 1. Qualitative composition of free amino acids demonstrated in the root xylem of the hybrid Sze DC 289 (Sap No. 1). The solvent was butanol-acetic acid-water (3 : 1 : 1) in the first dimension, and phenol-water (4 : 1) in the second one. The staining developer was ninhydrine, the fixative copper nitrate reagent. The dominance of amino acid-amides, i.e. asparagine and glutamine (Asn, Gln), is apparent

centration of asparagine in the xylem sap of the two hybrids examined here was substantially higher than that of glutamine in both samples, which corresponds to the fact that maize is a "C_4" type species as regards photosynthesis. The authors have also demonstrated (PINTÉR *et al.* 1977a, 1978a), that when the plant suffers from a water deficit, asparagine dominates in the leaves too.

A comparison of the data in Table 2 reveals that there were considerable differences between the sum amounts of total free amino acids and amides (point 5) in the two hybrids at both samplings. Hybrid Sze DC 289 transported nearly twice to four times as much total amino acids as hybrid K SC 360. However, prior to drawing any conclusions from the extent of amino acid synthesis in the roots, it is worth examining the most complex compounds formed in the two hybrids: the total protein.

The high protein concentrations transported by the hybrid K SC 360 compensated almost completely for the great differences shown in the amount of xylem sap in favour of the hybrid Sze DC 289. Thus a relatively small difference appeared in the protein outputs of the two hybrids (point 7) during both sap collections (7.1 and 11%, respectively). Hence, the considerable advantage of the xylem sap of Sze DC 289 in the synthesis and transport of free amino acids was scarcely realized in protein formation in the root system.

As regards the totalled concentrations of all inorganic and organic N-forms (point 10 in Table 2) the hybrid K SC 360 again attained a substantially higher level than Sze DC 289. In spite of this, the total N outputs of all nitrogen compounds measured in the xylem sap (point 11) showed higher values for Sze DC 289 than for K SC 360. The difference in favour of Sze DC 289 in total transported nitrogen was 91.7 and 56.6% respectively.

Table 2

Total free amino acid and amide outputs of xylem sap exudated in 12 hours by 10 decapitated roots of two maize hybrids (mg). Total protein concentration and output of xylem sap, and N-concentration and output of all inorganic and organic compounds measured (μg/ml and mg, respectively)

Concentrations and outputs	Sap collection			
	No. 1		No. 2	
	SzeDC 289	KSC 360	SzeDC 289	KSC 360
1. Total amino acid output; mg/sap of 10 roots	135.3	38.0	67.3	51.4
2. Glutamine output; mg/sap of 10 roots	18.0	1.5	16.3	6.1
3. Asparagine output; mg/sap of 10 roots	30.0	2.0	23.5	7.1
4. Total amide output; mg/sap of 10 roots	48.0	3.5	39.8	13.2
5. Total amino acid and amide output; mg/sap of 10 roots	183.3	41.5	107.1	64.6
6. Total protein concentration; mg/ml	0.75	2.10	1.15	2.25
7. Total protein output; mg/sap of 10 roots	112.5	105.0	117.3	105.7
8. Total output of all organic compounds measured; mg	295.8	146.5	224.3	170.3
9. N-output of all organic compounds measured; mg	47.3	23.4	35.9	27.2
10. N concentration of all inorganic and organic compounds measured; μg/ml	551.0	864.0	642.0	893.0
11. N output of all inorganic and organic compounds measured; mg/sap of 10 roots	82.8	43.2	65.6	41.9

The concentrations are averages of 4 replications; deviations from these (errors) are below $\pm 5\%$ of the averages.

The total nitrogen output under identical external conditions in the two hybrids with different genotypes was thus quite different on both occasions of sap collecting. However, this surplus of chiefly inorganic nitrogen, but also of nitrogen fixed in the form of free amino acid and amide in the hybrid Sze DC 289, was not manifested either in the dry matter of the stalks and leaves, or in the quality and quantity of the grain yield, as has been indicated in other papers (Pintér *et al.* 1977b, 1978a).

It was also found that the potassium output of the total xylem sap collected in 12 hours from 10 decapitated roots of hybrid Sze DC 289 was 50.8% higher on the first, and 116.9% higher on the second occasion of sap collection than that of K SC 360. This fact somewhat explains the higher level of xylem sap collected in 12 hours in hybrid Sze DC 289.

*

Prepared at the József Attila University, Department of Plant Physiology, and Cereal Research Institute, Szeged. G. Pálfi, L. Pintér, Zs. Pálfi

References

Amos, J. A.—Scholl, R. L. (1977): Effect of growth temperature of leaf, nitrate reductase, glutamine synthetase, and NADH-glutamate dehydrogenase of juvenile maize genotypes. Crop Sci., **17**, 445—448.

Anderson, W. P.—Aikman, D. P.—Meiri, A. (1970): Excised root exudation — a standing-gradient osmotic flow. Proc. Roy. Soc., **174**, 445—458.

BONAPARTE, E. E. (1975): The effect of temperature, daylength, soil fertility and soil moisture on leaf number and duration to tassel emergence in Zea mays L. Ann. Bot., **39**, 853—861.

CLARKSON, D. T. (1976): The influence on the exudation of xylem sap from detached root systems of rye (Secale cereale) and barley (Hordeum vulgare). Planta, **132**, 297—304.

COLOWICK, S. P.—KAPLAN, N. O. (1957): Methods in enzymology. 3. Acad. Press. Inc. Publishers, New York, 447.

DABIAN, A. T. (1973): Maize physiology. Rep. Cereal Improvement Program, Ibadan, IITA., 22—25.

DÉVAY, M.—GÁSPÁR, L. (1958): A fő- és oldalhajtás táplálkozásélettani kapcsolatainak vizsgálata kukoricán. Kukoricatermesztési kísérletek 1953—1956. (Nutrition physiology of main and lateral stalks in maize. Maize production experiments 1953—1956). Akadémiai Kiadó, Budapest.

GREENWAY, H. (1970): Effect of slowly permeating osmotica on metabolism of vacuolated and non-vacuolated tissues. Plant Physiol., **46**, 254—258.

IZMAYLOV, F. S.—ARMAN, R. A.—SMIRNOV, A. N.—Измаилов Ф. С.—Арман Р. А.—Смирнов А. Н. (1975): Транспорт аминокислот из корня в лист и обновление белков в различных органах проростков кукурузы. Физиология раст., **22**, 966—970.

KARMOKER, J. L.—VAN STEVENINCK, R. F. M. (1978): Stimulation of volume flow and ion flux by abscisic acid in excised root systems of Phaseolus vulgaris L. cv. Redland Pioneer. Planta, **141**, 37—43.

LANGE, B. (1961): Kolorimetrische Analyse. Verlag Chemie, Berlin.

LÁNG, I.—GÁTI, F. (1958): A réteges homokjavítás hatása a kukorica ásványi táplálkozására (Effect of layered sand improvement on mineral nutrition in maize). Agrártud. Oszt. Közl., **14**, 369—381.

MENGEL, K.—SIMIC, R. (1973): Effect of potassium supply on the acropetal transport of water, inorganic ions and amino acids in young decapitated sunflower plants (Helianthus annuus). Physiol. Plant., **28**, 232—236.

MOZHAEVA, L. V.—PILSHCHIKOVA, N. V.—KUZINA, V. I.—Можаева Л. В.—Пилщикова Н. В.—Кузина В. И. (1978): Значение неосмотического компонента корневого давления для нагнетания воды корнями. Изв. ТСХА, **1**, 3—11.

NÉMETH, J.—PINTÉR, L. (1975): Effects of plant density and spacing on the grain yield of hybrids. Maize Genetics Cooperation, Newsletter, **49**, 21—23.

PÁLFI, G. (1966): Comparison of the spectrum of amino-acids in the bleeding sap of wheat, maize and rice. Nature, **209**, 637.

PÁLFI, G. (1969): Az öntözés szükségességének a megállapítása és a szárazságtűrő növényfajták kiválogatása új, gyors módszerrel (Izatin-papír indikátor módszer) (A new, quick method of determining the necessity of irrigation, and selecting drought resistant plant varieties (Izatin-paper method). Növénytermelés, **18**, 25—34.

PÁLFI, G. (1970): A kultúrnövények szabad aminosav összetételének alakulása vízhiány és fiziológiai szárazság hatására (Changes in the free amino acid composition of cultivated plants as a response to water deficiency and physiological drought). A biológiai tudományok doktora disszertáció (D. Sc. thesis in biological sciences).

PÁLFI, G.—BITÓ, M.—PÁLFI, Zs.—Палфи Г.—Бито М.—Палфи Ж. (1973): Свободный пролин и водный дефицит растительных тканей. Физиология растений, **20**, 233—237.

PÁLFI, G.—JUHÁSZ, J. (1971): The theoretical basis and practical application of a new method of selection for determining water deficiency in plants. Plant and Soil, **34**, 503—507.

PÁLFI, G.—NÉMETH, J.—PINTÉR, L.—KÁDÁR, K.—BÖLKE, W. (1977): Rapid determination of drought-resistance of new rye, maize and lupin varieties with the live-wilting proline test. Acta Biol. Hung., Szeged, (in press).

PINTÉR, L.—KÁLMÁN, L.—NÉMETH, J.—PÁLFI, G. (1977a): Két eltérő vízigényű kukoricahibrid izolált növényi részeiben a prolin, összes- és szabad aminosav és oldható összfehérje tartalom vizsgálata (Proline, total and free amino acid, and total soluble protein contents in isolated plant parts of two maize hybrids with different water demands). Növénytermelés, **26**, 253—263.

PINTÉR, L.—NÉMETH, J.—PINTÉR, Z. (1977b): A levélfelület változásának hatása a kukorica (Zea mays L.) szemtermésére (Effect of change in the leaf area on grain yield in maize [*Zea mays* L.]). Növénytermelés, **26**, 21—27.

PINTÉR, L.—KÁLMÁN, L.—PÁLFI, G. (1978a): Determination of drought resistance in different genotype hybrids of maize (*Zea mays* L.) by field trials and biochemical tests. Maydica. **23**, 121—127.

PINTÉR, L.—PÁLFI, G.—PERCSICH, K.—PÁLFI, Zs.—DEÁK, J. (1979): Eltérő genotípusú kukorica (*Zea mays* L.) hibridek tápanyagfelvételének és hasznosításának vizsgálata

(Nutrient uptake and conversion by maize [*Zea mays* L.] hybrids of different genotypes). Növénytermelés, **28**, 23—27.

POTAPOV, N. G.—CSEH, E. (1955): Die Gesetzmässigkeiten der Blutung und der Stickstoffumwandlung in der Wurzel. Acta Bot. Hung., **2**, 147—157.

POTAPOV, N. G.—DÉZSI, L. (1954): Az őszi búza ásványi táplálkozása szabadföldi körülmények között (Mineral nutrition of winter wheat under field conditions). Ann. Biol. Univ. Hung., **2**, 51—55.

SCHRADER, B. VON—PRZEMECK, E. (1978): Untersuchungen über den N-Stoffwechsel und den N-Transport dekapitierter Wurzeln. Z. Pflanzenernähr. Bodenkd., **141**, 151—165.

SZUNDY, T. (1978): A tenyészterület hatása kukorica vonalak szemtermésének egyes tulajdonságaira (Effect of spacing on some properties of grain yield in maize lines). Növénytermelés, **27**, 123—130.

TENDILLE, C.—GERVAIS, C.—COIC, Y. (1972): Influence de la nature de l'alimentation azotée minérale sur la composition en substance azotées des séves exsudées des racines de mais et de tomate. C. R. Acad. Sci. Paris. Ser. D. 274. **10**, 1493—1496.

UKHINA, S. F.—Ухина С. Ф. (1976): Последействия кратковременной почвенной засухи у растений. Физиология растений, **23**, 204—206.

EFFECT OF LEAF AREA REDUCTION ON GRAIN YIELD AND YIELD COMPONENTS IN MAIZE (ZEA MAYS L.) HYBRIDS WITH DIFFERENT GENOTYPES

In maize production a reduction in the leaf area due to hailstorms, drought, Helminthosporium turcicum or rough detasselling often occurs in Hungary.

The effect of defoliation at the 10- and 16-leaf stage of maize was studied by SINGH—NAIR (1975a, 1975b). The removal of some of the leaf area at the 10-leaf stage resulted in a yield increase. Defoliation at the 16-leaf stage had a considerable yield-decreasing effect. NÉMETH—PINTÉR (1975) and PINTÉR *et al.* (1977) also found a substantial decrease in yield after defoliation at flowering time.

When studying the effect of defoliation on the yield components SINGH—NAIR (1975a) obtained reduced number, size and weight of grains. TOLLENAAR—DAYNARD (1978) found that defoliation during or immediately after flowering decreased the grain setting and the number of grains, while it reduced the thousand-grain-weight if carried out later. JOHNSON (1974) studied the relation between the area of leaves at different heights and the yield components, and demonstrated a close positive correlation between the area of leaves above the ear and the thousand-grain-weight. The number of grain-rows was found not to depend on the area of leaves at various heights.

In the course of our investigations answers were sought to the question of whether defoliation in hybrids with different genotypes would result in identical rates of change in the grain yield per plant, and also which of the yield components (length of ear, thousand-grain-weight, number of grain-rows) was responsible for the reduced grain yield.

In the experiment the following hybrids with different genotypes and vegetation periods, bred or maintained at the Cereal Research Institute, Szeged, and commercially produced in Hungary were used:

Sze TC 255	FAO 255	(GK71×GK72) 153R
Sze DC 289	FAO 289	(GK1×GK3) (GK2×W37A)
K SC 360	FAO 360	A90×153R
Sze SC 369	FAO 369	153R×Szv293
Sze DC 384	FAO 384	(GK73×C22) (GK5×WF9)
Bc 418	FAO 418	A632×153R-base
Sze MSC 515	FAO 515	(A632×GK17) GK13
Sze SC 565	FAO 565	Oh43/K×A632

Table 1

Trend in the air-dry grain yield of a plant (g)

Hybrid	Total leaves		Leaves above the main ear left	
	1976	1977	1976	1977
Sze TC 255	167.8	155.1	126.1	139.3
Sze DC 289	167.6	155.4	98.7	98.3
K SC 360	180.1	165.8	118.0	133.0
Sze SC 369	181.1	176.4	149.2	162.9
Sze DC 384	158.1	160.8	91.9	113.0
Bc 418	177.7	168.0	151.0	134.2
Sze MSC 515	251.5	207.6	148.5	135.6
Sze SC 565	227.7	204.2	160.1	172.3
$SD_{5\%}$	14.27	10.59	16.62	11.52
$SD_{1\%}$	18.95	13.93	22.13	15.15

* The decrease in yield obtained with only the leaves above the main ear left as a percentage of the control (total leaf area).

The experiment was carried out at the "Ságvári" experimental station of the Cereal Research Institute, Szeged, (at a latitude of 46° N under temperate climatic conditions) in 1976 and 1977.

When female flowering occurred the leaves of each hybrid were removed to different extents. The following treatments were, accordingly, set up: 1. control, with all the leaves left, 2. leaves above the main ear left, 3. half the leaves above the main ear left. In 1976 the treatments were performed with 15 plants per plot without replication, and in 1977 with 12 plants per plot, a total of 36 plants, with 3 replications, in a random block design. The 1976 experiment, which was set up without replication, was made possible by the homogeneity of the soil.

Planting was carried out in both years with a sowing gun, placing 3 seeds per hill at a row distance of 70 cm to obtain a stand density of 6 plants/m^2. By thinning at the 6—8-leaf stage single plants per hill were left.

Harvesting was carried out for each hybrid at 30% grain moisture content. The plants were processed one by one in an air-dry state (14% grain moisture content). The evaluation was also made for each plant separately. To check the reproducibility of the data a correlation coefficient (r) between the data of the two years was computed for each parameter and the significance was determined. The symbols * = $P_{5\%}$, ** = $P_{2\%}$, *** = $P_{1\%}$ and **** = $P_{0.1\%}$ were used to indicate the significance.

Assuming a linear correlation between the grain yield per plant and the yield components correlation coefficients were computed to assess the effect of the yield components on the grain yield. For the calculations the results of the different treatments and years were grouped according to hybrids.

With respect to the data for grain yield per plant in the two years (Table 1), correlation coefficients of r = 0.9625**** for the total leaf area, r = 0.8434*** for leaves above the main *under the influence of leaf area reduction*

Half the leaves above the main ear left		$SD_{5\%}$		$SD_{1\%}$		Yield decrease* (%)	
1976	1977	1976	1977	1976	1977	1976	1977
45.0	74.4	19.51	9.95	26.02	13.22	24.8	10.2
61.8	75.1	15.95	10.36	21.23	13.66	41.4	36.7
88.4	91.9	15.03	9.42	20.06	12.52	34.5	19.8
100.9	110.7	15.93	11.84	21.35	15.72	17.6	7.6
42.4	70.0	18.51	11.49	24.72	15.27	41.9	29.7
102.7	98.9	16.23	9.24	21.63	12.27	15.0	20.1
122.6	101.7	17.62	12.54	23.51	16.65	40.9	34.7
117.9	136.3	13.82	11.69	18.48	15.41	29.7	15.6
17.81	10.69						
23.62	14.06						

ear, and r = 0.8654*** for half the leaves above the main ear were obtained. This shows the reproducibility of our measurements. The different rates of defoliation decreased the grain yield per plant at the $P_{1\%}$ level in both years, with a single exception. The exception was the 1977 difference in grain yield per plant between the total leaves and the leaves above the main ear in Sze SC 369, which was only significant at the $P_{5\%}$ level.

Taking the $SD_{5\%}$ value obtained for the control (total leaf area left) into consideration, the hybrids showed the same order of succession in the two years as far as the grain yield data are concerned. In treatments representing the reduction of the leaf area this order of succession is modified, which suggests that in hybrids with different genotypes the same stress results in different rates of decrease in the grain yield per plant. This statement is confirmed by the percentage values for the yield decrease per hybrid (Table 1). The coefficient of correlation between the values of the two years is r = 0.7994**. These facts show the reproducibility of the trend and the difference in vulnerability between the hybrids.

For the length of the grain-covered ears in the two years (Table 2) correlation coefficients of r = 0.8347*** for the total leaf area, r = 0.8351*** for leaves above the main ear, and r = 0.7493* for half the leaves above the main ear were obtained, which proves the reproducibility of our measurements. The decrease in the length of grain-covered ear as a consequence of defoliation was caused by the fact that the seeds at the top of the ear were unable to develop, that is, grain setting was abnormal. In treatments representing the reduction of the leaf area the length of grain-covered ear decreased significantly at the $P_{1\%}$ level in both years in all hybrids, except in one case. The exception was the difference in 1976 between leaves above the main ear and half the leaves above the main ear in K SC 360.

For the grain-row data of the two years (Table 3) correlation coefficients of r = = 0.9938**** with the total leaf area, r = 0.9557**** with leaves above the main ear, and r = 0.7508* with half the leaves above the main ear were obtained, which proves the reproducibility of our data. The grain-row data of hybrids obtained in the control agree well. On the basis of significant differences at the $P_{5\%}$ level 5 of the 8 hybrids could be distinguished in 1976 and 4 in 1977. This confirms the well-known fact that the number of grain rows is genetically

Table 2

Trend in grain-covered ear length (cm) under the influence of leaf area reduction

Hybrid	Total leaves		Leaves above the main ear left		Half the leaves above the main ear left		$SD_{5\%}$		$SD_{5\%}$	
	1976	1977	1976	1977	1976	1977	1976	1977	1976	1977
Sze TC 255	18.2	17.4	15.7	15.4	9.3	12.9	2.87	1.13	3.83	1.49
Sze DC 289	16.5	16.2	13.6	13.4	10.9	11.4	2.02	0.99	2.70	1.31
K SC 360	18.0	18.4	14.1	14.9	13.7	13.6	0.89	0.98	1.19	1.30
Sze SC 369	19.7	19.3	16.9	17.5	14.6	14.6	1.15	0.85	1.54	1.13
Sze DC 384	16.1	15.6	12.1	13.9	8.3	12.1	1.98	0.96	2.65	1.21
Bc 418	18.1	18.1	16.3	15.2	14.4	13.6	1.31	0.70	1.76	0.93
Sze MSC 515	19.5	18.0	14.6	15.4	11.9	13.8	0.97	0.95	1.30	1.26
Sze SC 565	20.4	18.2	16.4	16.0	14.2	13.8	1.11	0.71	1.49	0.94
$SD_{5\%}$	1.05	0.81	1.35	0.75	2.24	1.05				
$SD_{1\%}$	1.39	1.06	1.78	0.99	2.96	1.37				

Table 3

Trend in number of grain-rows (n) under the influence of leaf area reduction

Hybrid	Total leaves		Leaves above the main ear left		Half the leaves above the main ear left		$SD_{5\%}$		$SD_{1\%}$	
	1976	1977	1976	1977	1976	1977	1976	1977	1976	1977
Sze TC 255	12.8	12.7	11.5	12.1	7.5	11.4	2.30	0.85	3.08	1.11
Sze DC 289	14.7	14.7	14.1	14.6	12.4	12.8	ns	0.78	ns	1.03
K SC 360	13.1	12.8	12.1	12.4	10.9	11.6	1.05	0.93	1.40	1.22
Sze SC 369	11.7	12.2	12.0	12.1	11.7	11.9	ns	ns	ns	ns
Sze DC 384	16.3	16.6	14.0	15.5	10.2	14.5	2.26	0.99	3.02	1.31
Bc 418	14.9	14.6	14.8	14.7	14.1	14.0	ns	ns	ns	ns
Sze MSC 515	18.3	18.4	17.3	16.4	14.5	13.3	1.37	1.00	1.84	1.32
Sze SC 565	17.6	17.3	17.3	17.1	17.1	17.3	ns	ns	ns	ns
$SD_{5\%}$	1.03	0.86	1.24	0.81	2.24	0.94				
$SD_{1\%}$	1.37	0.90	1.32	1.07	2.97	1.24				

ns = no significant difference

determined. The decrease in the number of grain-rows as a response to defoliation thus indicates an irregularity in the fertilization.

In 2 of a total of 16 observations made over two years the removal of leaves below the main ear resulted in a significant decrease in the number of grain-rows compared to the control (in Sze DC 384 at $P_{5\%}$, in Sze MSC 515 at $P_{1\%}$). When only half the leaves above the main ear were left, a significant decrease in the number of grain-rows compared to the control was found in 9 of the 16 cases. In 3 of the hybrids, however, the treatments caused no change in the number of grain-rows in either of the two years (Sze SC 369, Bc 418, Sze SC 565). The above results show that the same extent of defoliation disturbs the fertilization of hybrids with different genotypes in varying degrees.

The coefficients of correlation between the thousand-grain-weight data of the two years (Table 4) were r = 0.9049*** with the total leaf area, r = 0.7590* with leaves above the main ear, and r = 0.9375**** with half the leaves above the main ear left, which again shows the reproducibility of our data. The decrease in the thousand-grain-weight as a response

Table 4

Trend in thousand-grain-weight (g) under the influence of leaf area reduction

Hybrid	Total leaves		Leaves above the main ear left		Half the leaves above the main ear left		$SD_{5\%}$		$SD_{1\%}$	
	1976	1977	1976	1977	1976	1977	1976	1977	1976	1977
Sze TC 255	362.2	332.4	349.8	301.5	263.7	309.9	79.20	19.99	ns	23.90
Sze DC 289	323.5	285.1	318.0	273.8	270.2	269.4	41.11	ns	ns	ns
K SC 360	339.3	343.0	307.5	333.3	314.0	322.9	17.41	11.57	23.27	15.37
Sze SC 369	380.7	386.6	380.8	377.2	369.7	355.9	ns	16.80	ns	22.32
Sze DC 384	257.5	259.3	249.9	244.6	204.7	250.6	ns	ns	ns	ns
Bc 418	316.5	310.3	312.3	306.0	310.3	311.7	ns	ns	ns	ns
Sze MSC 515	346.2	352.8	323.7	325.0	312.5	336.7	28.04	13.94	35.12	18.52
Sze SC 565	314.3	308.7	308.8	309.4	213.0	246.6	18.95	14.30	25.33	18.85
$SD_{5\%}$	18.83	10.99	26.99	15.05	58.05	17.68				
$SD_{1\%}$	25.01	14.46	35.85	19.79	77.11	23.25				

ns = no significant difference

Table 5

Correlation between grain yield per plant and yield components (r)

Hybrid	Number of grain-rows	Thousand-grain-weight	Length of grain-covered ear
Sze TC 255	0.8832**	0.8052	0.9788****
Sze DC 289	0.8301*	0.6189	0.9875****
K SC 360	0.9532***	0.7960	0.9497***
Sze SC 369	0.4190	0.8216*	0.9791****
Sze DC 384	0.9064**	0.7758	0.9623***
Bc 418	0.0568	0.4086	0.9757****
Sze MSC 515	0.8640*	0.6973	0.9224***
Sze SC 565	0.7223	0.8340*	0.9657***

* = $P_{5\%}$; ** = $P_{2\%}$; *** = $P_{1\%}$; **** = $P_{0.1\%}$

to defoliation shows that the grain filling is abnormal. The removal of the leaves below the main ear only resulted in a significant decrease in thousand-grain-weight at the $P_{1\%}$ level in a single case (K SC 360 in 1976) out of a total of 16 observations in two years, compared to the control. It was only in 3 hybrids each year that the removal of the leaves below, and half the leaves above the main ear did not significantly decrease (at the $P_{5\%}$ or $P_{1\%}$ level) the thousand-grain-weight. On the basis of the above it can be established that the same rate of defoliation disturbs the grain filling in hybrids with different genotypes to varying extents.

The correlation between the grain yield and the yield components examined is shown by the correlation coefficients in Table 5. The table reveals that the reduction of grain yield per plant is accounted for primarily by a decrease in the length of grain-covered ear, to some extent by the lower number of grain-rows, and least of all by the reduced thousand-grain-weight. There seemed to be a correlation between the changes in the latter two yield components in the individual hybrids. In hybrids where no reliable correlation was found between the number of grain-rows and the grain yield, a significant correlation was obtained, with one exception (Bc 418), between the thousand-grain-weight and the grain yield. This shows that under the stress caused by defoliation the plants are unable to produce a higher number of grains. This phenomenon is also a property characteristic of the genotype.

*

Prepared at the Cereal Research Institute, Szeged.

L. PINTÉR

References

JOHNSON, G. R. (1974): Analysis of the genetic relationship between several yield components of maize and leaf area at specific leaf positions. Crop Sci., **14**, 559–561.

NÉMETH, J.—PINTÉR, L. (1975): Effects of plant density and spacing on the grain yield of hybrids. Maize Genetics Cooperation News Letter, **49**, 21–23.

PINTÉR, L.—NÉMETH, J.—PINTÉR, Z. (1977): A levélfelület változásának hatása a kukorica (*Zea mays* L.) szemtermésére (Effect of changes in leaf surface area on grain yield in maize [*Zea mays* L.]). Növénytermelés, **26**, 21–27.

SINGH, R. P.—NAIR, K. P. P. (1975a): Defoliation studies in hybrid maize. I. Grain yield, quality and leaf chemical composition. J. Agric. Sci., **85**, 241–245.

SINGH, R. P.—NAIR, K. P. P. (1975b): Defoliation studies in hybrid maize. II. Dry-matter accumulation, LAI, silking and yield components. J. Agric. Sci., **85**, 247–254.

TOLLENAAR, M.—DAYNARD, T. B. (1978): Effect of defoliation on kernel development in maize. Can. J. Plant Sci., **58**, 207–212.

ULTRASONIC TREATMENT ON MAIZE SEED

An increasing number of publications have dealt recently with the stimulation of seeds or developing plants by physical methods. Experience shows that a higher percentage of seeds treated in this way germinate, the initial development of the seedlings accelerates, and under optimum conditions the yields may even be larger. Such effects have been observed after various high energy ionizing radiations, under the influence of electric and magnetic fields, ultrasonic irradiation, and most recently in consequence of laser radiation.

Ultrasonic experiments on plants and seeds have a history of several decades. The first observations on living plants were made by JOHNSON (1929). He found that ultrasonic pressure and suction waves destroyed the plants, since carbonic acid accumulated in the plant cells as a consequence of the ultrasonic irradiation, and owing to the great difference in pressure the cell membrane burst. In the second half of the 1940s more intensive research began, through which it has become known that a short period of low intensity radiation stimulates the germination of seeds and the development of plants, while high intensity radiation of longer duration may have an inhibitory or even lethal effect. In the case of low rate irradiation BERENTS (1948) observed the acceleration of germination in beans and peas. When irradiated with high doses, on the other hand, the seeds stopped developing after a week, and the plants died. WOLTERS (1958) studied the effects of ultrasonic irradiation on barley grain and bean seed. He performed the treatments at various frequencies and at intensities of 0.05—12 Watt per cm^2, and established what treatment parameters were required if a more favourable germination percentage of seeds were to be attained compared to the control. According to his investigations if the seeds were dried after the treatment this diminished or completely counteracted the effect of the ultrasonic irradiation. HESSE (1952) found the optimum treatment parameters to be specific for species and variety. RUSU—LUCA (1960) reported on favourable results obtained when treating maize. For the irradiation of the seeds an ultrasonic generator operated at 1.4 MHz was used; the treatment period was 3, 5 and 7 minutes, and the intensity 012, 0.23, 0.30 and 0.51 Watt/cm^2. With 3 minutes of irradiation ATTAULLAEV (1965) achieved a 13.4% yield increase in the variety VIR-156. Under identical conditions the same author obtained a 31% yield increase in one maize hybrid when irradiation was carried out for one minute using a 1.25 MHz ultrasonic generator. VERES (1973) experimented with ultrasonic irradiation on the seeds of field crops. According to her investigations a few minutes of irradiation resulted in earlier germination, increased the germination percentage, and caused a 10—30% increase in yield. The same author determined the optimum time of treatment, at which the yield stimulation appeared, for several horticultural crops. Further she mentions experiments related with the large-scale application of the method, i.e. with the ultrasonic irradiation of larger quantities of seed. GUIDA—GORSHKOV (1974), on the other hand observed no increase in the germination percentage, but found that the germinative power improved and the green mass increased as a result of the ultrasonic treatment of maize seed. They treated the seed for 5 minutes at varying frequencies (450, 960 or 2880 KHz) and intensities (2, 6 or 8 Watt/cm^2) and attained quicker emergence, a shorter vegetation period and a 5.2% increase in yield.

Some of the ultrasonic irradiation in the present experiment was carried out with a Kretz ultrasonic generator operating at 800 KHz frequency with a barium titanate head with an approx. 9 cm^2 active surface. The intensity could be varied from 0 to 3.6 Watt/cm^2. The radiation treatments were applied at close quarters by placing a 100 ml glass vessel with a rubber membrane bottom immediately over the transducer head and coupling it with distilled water. During the treatment the seeds, which were placed in all cases in 80 ml water, were mechanically stirred in order to ensure uniform irradiation.

For the higher intensity treatments a Lehfeldt ultrasonic generator with a quartz-crystal transducer and equipped with a circulatory water cooling was used. Here again the frequency was 800 KHz, while the maximum intensity was 8 Watt/cm^2. Seed of the maize hybrid Szegedi 71 were treated in water contained in a glass vessel with a rubber membrane bottom but this time the bottom of the glass vessel was at a distance of 3 cm from the transducer.

The transducer was water cooled in both apparatuses. Additional cooling only had to be applied to the seed in the 8 Watt/cm^2 apparatus.

In the first phase of the experiment the parameters at which the germinating ability of the seeds considerably decreased or was reduced by 50% were determined for both ultrasonic apparatuses. The aim was to elaborate treatments which could be expected to result in stimulation when applied in field trials. The germination experiments, as already men-

Table 1

Effect of irradiation at 3 and 8 W/cm² intensity on the germinating ability of the maize hybrid Szegedi-71

Intensity, W/cm²		Treatment period (minutes)									
		C	5	10	15	20	25	30	35	40	45
3	Average	92.81	94.0	93.8	94.5	94.0	93.3	76.0	65.7	27.3	3.7
	Deviation	1.47	1.67	1.94	2.17	2.25	2.00	5.41	5.99	1.67	1.05
	$SD_{5\%}$	—	2.34	2.56	2.69	2.83	2.59	5.88	6.47	2.34	1.89
8	Average	92.5	93.8	94.4	94.7	88.7	82.7	52.4	14.3	—	—
	Deviation	1.63	1.83	1.37	1.47	2.32	3.90	2.32	2.03	—	—
	$SD_{5\%}$	—	2.59	2.24	2.31	2.98	4.42	2.98	2.75	—	—

tioned, were carried out for the maize hybrid Szegedi-71 with 6×100 seeds in Petri dishes, as laid down in the Hungarian standard. The germination percentages relating to the different treatment periods, the standard deviations of the data, and the values for significant differences compared to the control (on the basis of the standard deviation in lines with similar elements) are shown in Table 1.

In the course of these investigations no significant increase was found in the germination percentage of the treated maize grains because of the high rate of germination in the control itself.

It can be seen from the data that the germination curves have a non-significant ascending phase in the shorter, generally 5 to 15 minute treatment periods at both intensities (a similar trend was observed with seeds of other plants too). Treatment periods longer than this reduce the germination percentage.

At an irradiation intensity of 3 Watt/cm² a 30-minute treatment resulted in a significant decrease in the germination percentage, and in the case of treatments longer than 35 minutes more than 50% of the seeds were destroyed. At an intensity of 8 Watt/cm² a 20-minute treatment significantly reduced the germination percentage, while with treatments longer than 30 minutes more than 50% of the seeds were destroyed. At an intensity of 8 Watt/cm² a 20-minute treatment significantly reduced the germination percentage, while with treatments longer than 30 minutes more than 50% of the seeds lost their germinating ability.

In the first phase of the experimental work it was noted that 5 to 15 minutes of irradiation resulted in earlier germination compared to the control. It was therefore thought necessary to study the course of germination. For this purpose 1—7 days after the treatment a count was made of seedlings which had radicles at least 2—3 mm long. The results are shown in Fig. 1.

On the first day only seeds treated for 5—15 minutes began to germinate, and until the fourth day of germination their germinating power was significantly higher than that of the control. On the fifth day, when the control had also reached an 82% level of germination, the difference was no longer significant. However, the earlier germinating plants showed a higher dry matter production at all stages.

To clarify the stimulative effect a small plot field trial was set up with 4 replications. Szegedi-71 hybrid maize seeds were given ultrasonic irradiation treatment at 3 Watt/cm² and 8 Watt/cm² intensity, for 5, 10 and 15 minutes. Some of the treatments were carried out in

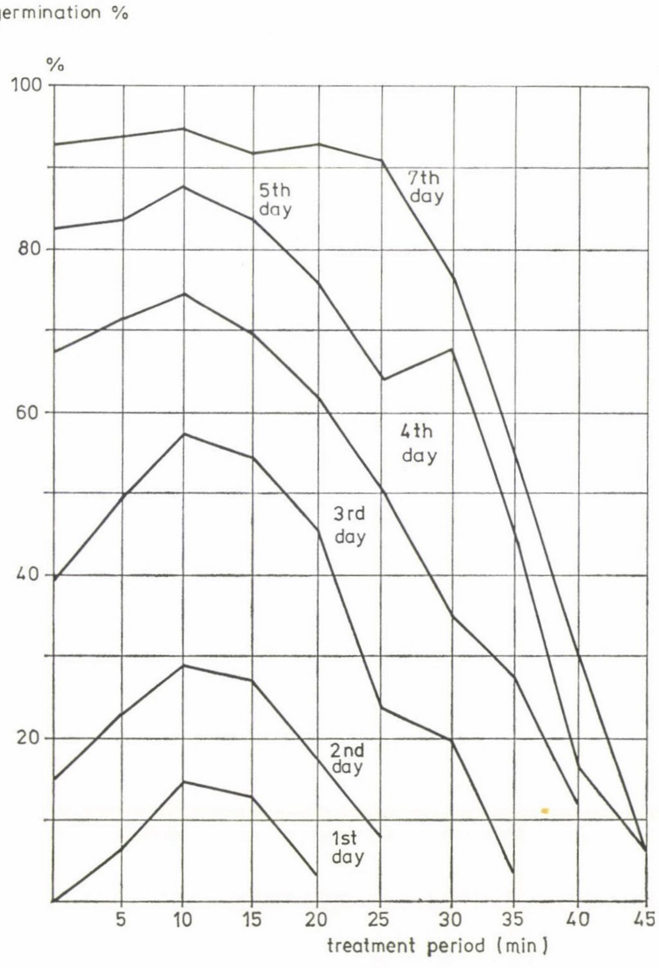


Fig. 1. **Effect of ultrasonic treatment on the course of germination in the maize hybrid Szegedi-71 on the 1st, 2nd, 3rd, 4th, 5th and 7th days**

distilled water, and the rest in 1% Wuxál microelement culture solution. Untreated dry seeds were sown as a control (Table 2).

As can be seen from the data in Table 2 the best crop results were obtained with the shorter, higher intensity treatment. The use of 1% Wuxál solution proved advantageous because it caused a further increase in yield in the case of the 5—10 minute treatments, and lessened the yield reduction occurring after a longer period of treatment. In this case the temperature of the treatment medium did not change compared to the distilled water treatment, regardless of whether the intensity of radiation was 3 or 8 Watt/cm².

The 5-minute treatment at 8 W/cm² showed a significantly better result than any of the 3 W/cm² treatments. At an intensity of 8 W/cm² only a short (5 minute) treatment is justified, since a longer irradiation time may substantially reduce the yield. At an intensity of 3 W/cm² the largest yield was attained with the 10-minute treatment. The 15-minute treatment was found to be unfavourable in both cases, as it only resulted in a slight (if any) yield increase compared to the control.

Table 2

Effect of ultrasound on yield per plot in the maize hybrid Szegedi-71

	Yield, kg/plot			
	in distilled water		in 1% Wuxál solution	
	3 W/cm²	8 W/cm²	3 W/cm²	8 W/cm²
5 minutes	29.0	34.5	30.3	37.3
10 minutes	28.9	28.0	30.9	36.2
15 minutes	19.8	18.7	27.2	28.4

Control: 28.2 kg/plot.
$LSD_{5\%}$ = 2.4 kg/plot between the two intensities.
$LSD_{5\%}$ = 2.8 kg/plot between the irradiation media (water and Wuxál solution).

It can be established from these experiments that ultrasonic treatments of optimum length and intensity improve germination, accelerate the initial rate of germination and the metabolic processes of the seeds, and increase their permeability, as has been suggested by a number of authors.

As regards the permeability, experiments were carried out in order to study the P^{32} uptake of maize grains. Grains irradiated for 10 minutes took up three to four times as much P^{32} isotope from a phosphoric acid solution at low concentration as the untreated ones. It can thus be assumed that ultrasonic irradiation at 3 W/cm² also promoted the uptake of the Wuxál-solution and of the microelements. Finally it can be noted that the primary ultrasonic effects (sound pressure, radiation pressure, interfacial friction, absorption and cavitation) are responsible for the physiological stimulation and inhibition.

On the basis of the experience obtained, the ultrasonic stimulation of seeds of horticultural plants is planned. Considering the smaller size of the seeds in this case, larger amounts of seed could be irradiated at a time, and there is also the possibility of increasing the volume irradiated to a considerable extent.

*

Prepared at the Debrecen University of Agricultural Sciences, Department of Physics and Department of Plant Production, Debrecen, and the Research Institute of the Debrecen University of Agricultural Sciences, Karcag.

J. Nagy, K. Pásztor, J. Lazányi

References

Attaullaev, N. A.—Аттаулев Н. А. (1965): Действие ультразвука на урожай дынь и кукурузы. Вест. сх науки, **2**, 27—31.
Berents, J. (1948): Untersuchungen über Keimveränderungen an Erbsen (*Pisum sativum*) durch Ultraschall. Dias. (1948) Erlangen.
Guida, N. J.—Gorshkov, A. E. —Гуйда Н. Я.—Горшков А. Е. (1974): Влияние ультразвука на рост и развитие кукурузы. Биол. журн. Армении, Ереван, **7**, 49—53.
Hesse, R. (1952): Zur Wirkung der Ultraschallbehandlung von Samen auf die Keimung und das nachfolgende Wachstum von Pflanzen. Flora, **139**, 556—585.
Johnson, C. H. (1929): The lethal effects of ultrasonic radiation. J. Physiology, **2**, 356.
Rusu, I.—Luca, A. (1960): Cercetári privind influenta ultrasunetelor asupara productiei la porumb. Institutul Agronomic "Professor Ion Ionescu De la Brand", Lucrári stiintifice, Bucuresti.
Veres, É. (1973): Ultrahang a biológiában (Ultrasound in biology). Dacia Könyvkiadó, Kolozsvár.
Wolters, K. (1958): Zur Wirkung von U.S. Westdeutscher Verl. Köln-Opladen.

ANATOMY OF WILD ORCHIDS IN HUNGARY. I. TISSUE STRUCTURE OF LEAF AND FLORAL AXIS

After the completion of a taxonomic and geobotanical monograph on the orchids of Pannonia and the Carpathian Basin (Borsos 1952/54, 1959, 1960, 1961, 1962, 1963, 1964, 1968, Borsos—Soó 1966) work was started in 1974 on the anatomy of these plants. Since the anatomy of wild orchids in Hungary had not been dealt with previously, the author's aim was to carry out histological studies on them. The present paper gives an account of the results obtained in anatomical examinations of the leaf and stem.

The world literature on orchids is abundant and covers all special fields; but there are comparatively few publications on the anatomy of these plants. A comprehensive characterization of all European species is found in the work of Camus (1928). Two years later a work was published by Solereder—Mayer (1930) which discussed wild genera of the *Orchidaceae* family, some from the tropics and some from the temperate zone, from a histological point of view. A detailed orchid monograph by Ziegenspeck (1936) gives an anatomical characterization of several genera and species. In several anatomical manuals (Esau 1969, Metcalfe 1960) brief references to the cytological or histological structures of these plants are found.

The experimental material was collected from many sites in Hungary when the orchids were flowering. The tissue structure of the leaf was studied in the following taxa:

Anacamptis pyramidalis (L.) Rich. (Dabas)
Dactylorhiza incarnata (L.) Soó (Dabas)
D. maculata (L.) Soó (in the neighbourhood of Esztergom)
Gymnadenia conopea (L.) R. Br. et Ait. (Dabas)
Ophrys sphegodes Mill. (Dabas)
Orchis coriophora L. (Dabas)
O. laxiflora Lam. ssp. *palustris* (Jacq.) A. et G. (Dabas)
O. militaris L. (Dabas)
O. pallens L. (Bakony Hills: Tobánhegy)
O. purpurea Huds. (Bakony Hills: Tobánhegy)
Platanthera bifolia (L.) Rchb. (Vértes Hills)

In addition four further species were subjected to anatomical investigations on the stem:

Cephalanthera Damasonium (Mill.) Druce (Vértes Hills)
C. longifolia (Huds.) Fritsch (Vértes Hills)
C. rubra (L.) Rich. (Vértes Hills)
Cypripedilum calceolus L.

In our studies on leaf anatomy, preparations taken from the upper and lower epidermis of the middle section of leaves growing on the lower third of the flower stem were used, together with cross-sectional preparations. The epidermis preparations were used to study the shapes of the epidermis cells and the stomata and the pattern of the cell-walls, measurements were made on the size of the cells and stomata, and the number and distribution of cells and stomata per unit surface area (1 mm^2) and the stoma index were determined. In the evaluation a hundred measurements on each of five specimens per taxon were used.

The anatomy of the stem was examined on preparations of cross and longitudinal sections from the middle and lower third of the flower stem.

All the sections were made from fresh plant material; permanent preparations were made from the epidermis, while the cross-section preparations of the stem were made by manual dissection and double staining (Sárkány—Szalai 1964, Újhelyi 1954). The leaf epidermis preparations of the last four species were not satisfactory, so they are not described in the paper.

1. *General characterization of the tissue structure of the leaf.* The leaves of all the taxa studied were of the isolateral homogeneous type. The cells of the upper and lower epidermis differ in size. In the upper epidermis the cells are generally larger than in the lower epidermis. This difference in size may be quite considerable (detailed descriptions are given below for the individual species). The outer, tangential walls of the cells generally have a cuticle; when seen from above they are mostly straight, slightly bent, curved or wavy. In some species the upper epidermis is covered with hair. There are stomata between the epidermis cells; they are mostly round or oval and have no accessory cells. The leaves of certain species also have a greater or lesser number of stomata on the upper epidermis. The stomata differ in size according to whether they are on the upper or on the lower epidermis. The number of epidermis cells per unit surface area (1 mm^2) is connected with the dimensions of the cells and the number and size of the stomata, and depends on whether they originate from the upper or lower epidermis of the leaf.

The mesophyllum, which is rich in chloroplasts, is composed of spongy parenchymatous tissue. In the middle of the leaf, around the main vein, it is generally 6—10 cell-rows thick, while towards the edges the thickness is 3—6 cell-rows. The cells are polygonal or irregularly rounded, arranged in a closely or loosely fitting pattern with a greater or lesser amount of intercellular space between them. The raphid-containing cells also appear in the mesophyllum, with a frequency varying with the species (Kohl 1899).

The vascular bundles which run parallel along the length of the leaf generally have a circular cross-section and are of the collateral closed type, in which the phloem is adjacent to the lower, and the xylem to the upper epidermis; they are surrounded by a parenchyma sheath. The vascular bundles in the middle of the leaf are usually larger, while they decrease in size towards the edge of the leaf.

Differences between the species or genera are negligible with regard to the structure of the mesophyllum, but much more significant as regards the structure of the epidermis, as shown by the epidermis preparations. The structure of the epidermis is specific to the species, almost without exception. Therefore, in discussing the individual species full particulars will be given of the results of the examinations.

2. *General description of the tissue structure of the stem.* The cross-section of the stem is circular, though the costate stem of many species gives a slightly wavy pattern in the cross-section.

The epidermis consists of a single cell-row of larger or smaller, close-set cells, with a greater or lesser number of somewhat sunken stomata. In some species multicellular hairs or possibly emergences appear on the epidermis. The cells are square, or slightly flattened in a radial direction, with a thinner or thicker cuticle on the outer surface, though this may be missing altogether.

The parenchymatous primary cortex ground tissue under the epidermis may differ in thickness from 2—3 to 10—12 cell-rows. The cells are usually irregular, or rounded, with a larger or smaller intercellular space between them; the cell-walls are thin. The cells contain a large number of chloroplasts. In some species leaf-trace bundles also appear in this tissue (see detailed description).

The sclerenchyma is usually 3—6 cell-rows thick, though it may be much thicker than that; e.g. in *Orchis laxiflora* ssp. *palustris* it is composed of 8—9 cell-rows. The cell-walls are thickened to a greater or lesser extent.

The smaller of the vascular bundles are either found in the sclerenchyma cylinder, or adjoin it, imbedded in the ground tissue of the parenchymatous stele. In the latter case a multicellular sclerenchyma cap is usually found between the phloem and the sclerenchyma cylinder. In cross-section these bundles are also seen to form a circle, mostly placed close to one another. The larger bundles are found in the centre of the stem, scattered in the parenchymatous medulla.

The vascular bundles are of the collateral closed type. The phloem is composed of sieve-tubes, accessory cells and phloem fibres; the xylem consists of tracheides, tracheae and wood-parenchyma. The phloem is generally larger than the xylem. In a number of species a cap composed of sclerenchyma cells, the walls of which are thickened to a greater or lesser extent, can also be found above the phloem of the scattered vascular bundles.

The parenchymatous medulla consists of polygonal or rounded cells, which generally become larger towards the centre. There is little intercellular space. In a number of taxa there are breaks in the medulla, so large cavities are sometimes formed in the interior of the stem.

There are considerable differences between the species and genera of wild orchids in the tissue structure of the stem. These will be discussed in detail in the characterization of the individual species. The anatomical structures of the leaf and stem in the different taxa are described below in full detail.

Anacamptis pyramidalis (L.) Rich.

Leaf. The cells of the lower epidermis are hexagonal when viewed from above, and are longish, with straight walls. The average size of the cells is 52.0 $\mu \times 101.8\ \mu$. The number of cells per unit surface area (1 mm^2) is 33.19. There is a large number of roundish, slightly oval stomata with an average size of 49.8 $\mu \times 54.4\ \mu$. The average number of stomata per mm^2 is 9.94. The stoma index is 23.04 (Fig. 1*a*).

The cells in the upper epidermis are larger than those in the lower one; their average size is 96.0 $\mu \times 136.2\ \mu$. The cell-wall is straight or slightly curved. There are no stomata. The number of epidermis cells per mm^2 is 13.73. In cross-section the cells of the lower epidermis are somewhat compressed in a radial direction, while those of the upper epidermis are tangentially slightly elongated. The mesophyllum consists of 6—8 rows of parenchyma cells with rounded walls, rich in chloroplasts. There is little intercellular space between these cells (Fig. 1*b*).

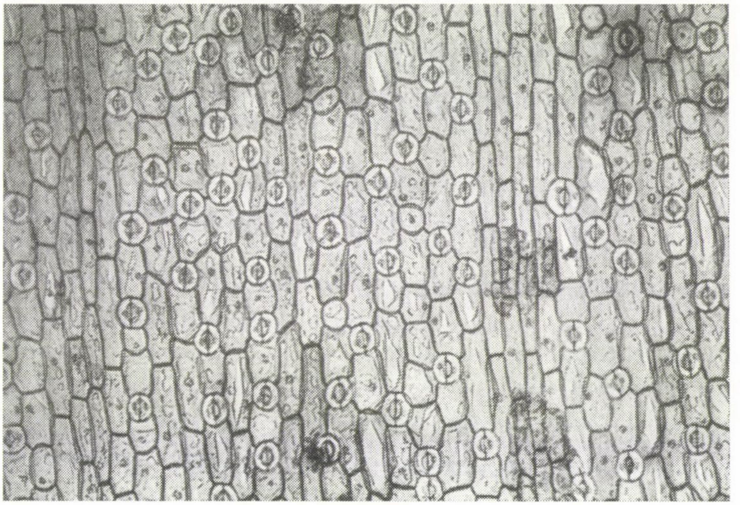


Fig. 1a

Stem. It has an almost circular, or slightly undulating circular cross-section. The outer, tangential wall of the single row of epidermis cells is slightly cuticular. The cells show some radial elongation and are close-set, with stomate scattered between them. Under the epidermis there is a five cell-row parenchymatous cortex ground tissue, the cells of which are polygonal and contain chloroplasts. There are larger or smaller intercellular spaces between the cells. There are leaf trace bundles in this layer, which form a circle in cross-section. Within this,

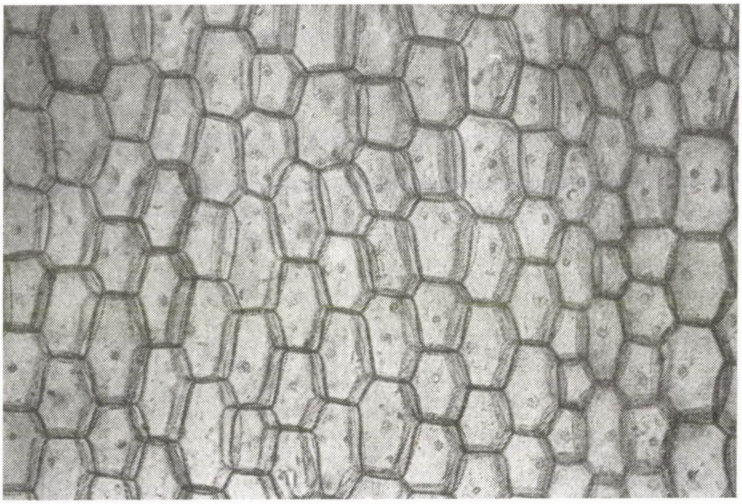


Fig. 1b

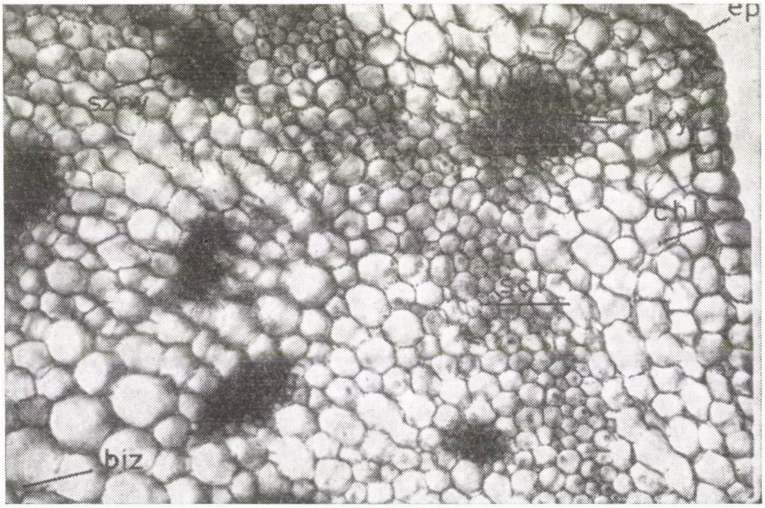


Fig. 1c

***Fig. 1.** Anacamptis pyramidalis. a* — Detail of the lower leaf epidermis (10× obj., 3.5× oc.); *b* — Detail of the upper leaf epidermis (10× obj., 3.5× oc.); *c* — Cross-section detail of stem (10× obj., 3.5× oc.). ep = epidermis, chl = chlorenchyma, lny = leaf trace bundle, szny = vascular bundle, scl = sclerenchyma ring, bsz = medulla

in the central cylinder, a sclerenchyma ring 4—5 cell-rows thick is seen, but here the cell-walls are only slightly thickened. This sclerenchyma ring is adjoined by collateral closed vascular bundles in the parenchymatous stele ground tissue, thinly spaced in a circle. The vascular bundles are mostly scattered towards the interior of the stem. The phloem is generally larger than the xylem. There is no sclerenchyma cap above the phloem (Fig. 1c).

Dactylorhiza incarnata (L.) Soó

Leaf. In the lower epidermis the cells are longish when seen from above, with straight walls. The average size of the cells is 57.3 $\mu \times$ 133.8 μ. There are a large number of oval-shaped stomata with an average size of 54.2 $\mu \times$ 74.8 μ. The number of epidermis cells is 28.74/mm^2, and the number of stomata 10.0/mm^2. The stoma index is 2.5.

The cells of the upper epidermis are much larger than those of the lower epidermis. There are no stomata. The cell-walls are straight. The average size of the cells is 69.6 $\mu \times$ 280.3 μ. The number of epidermis cells is 15.8/mm^2.

Stem. The outer tangential walls of the epidermis cells are convered by a thick cuticle; there are stomata between the cells. The chlorenchyma layer consists of 3—4 rows of rounded cells with many intercellular spaces between them. Below this layer (in cross-section, towards the interior of the stem) the sclerenchyma ring is 3—4 cell-rows thick and the cells are somewhat lignified. In the sclerenchyma ring a few small collateral closed vascular bundles, arranged in a circle, can be seen. Among the rounded cells of the parenchymatous stele ground tissue, in an inner ring, the other, larger vascular bundles are placed. In the centre of the stem there are breaks in the medulla and a large cavity fills the interior of the stem.

Dactylorhiza maculata (L.) Soó

Leaf. The cells of the lower epidermis are medium large with an average size of 74.2 $\mu \times$ 125.2 μ. The cell-walls are curved or slightly undulating. There is a large number of stomata, which are roundish in shape; their average size is 57.6 $\mu \times$ 67.2 μ. The number of epidermis cells is 19.79/mm^2, and the number of stomata 6.4/mm^2. The stoma index is 24.43 (Fig. 2a).

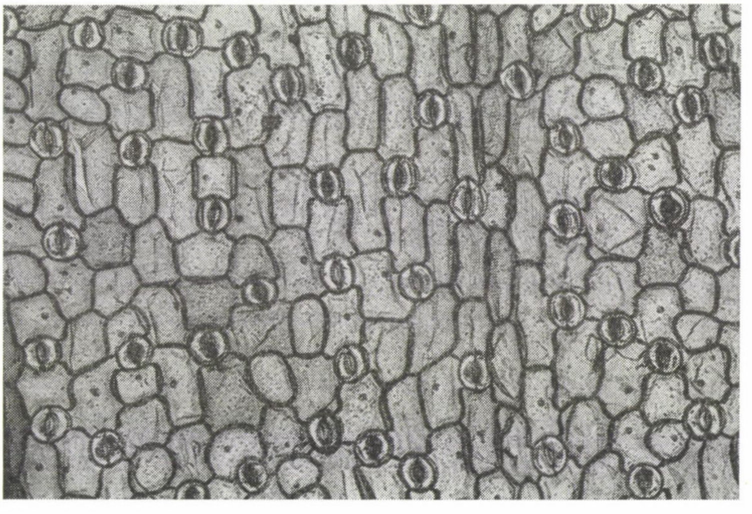


Fig. 2a

In the upper epidermis the cells are large: 115.1 $\mu \times 150.4\ \mu$ on average. The **cell-wall is straight**, or at most slightly curved. The stomata, which are few in number, have a **roundish shape** and an average size of 67.2 $\mu \times 77.0\ \mu$. The average number of epidermis cells is **9.98/mm²**, and the number of stomata 1.26. The stoma index is 11.20 (Fig. 2*b*).

The mesophyllum consists of 6—9 rows of close-set cells forming a parenchyma tissue rich in chloroplasts. Raphid-containing cells are few.

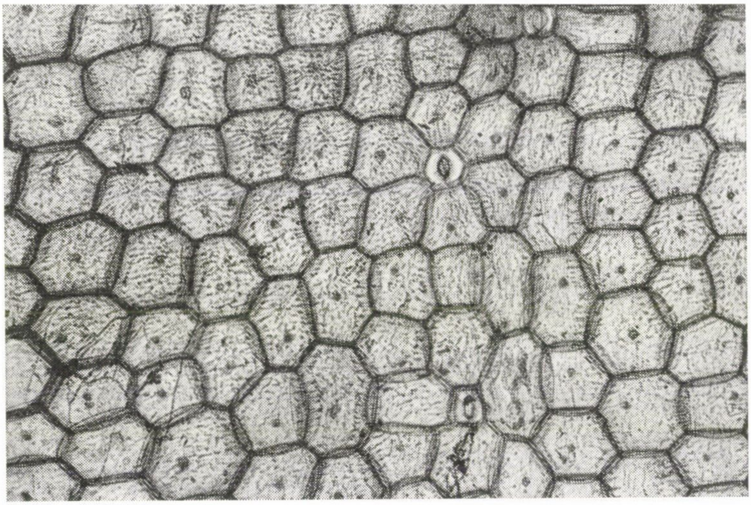


Fig. 2b

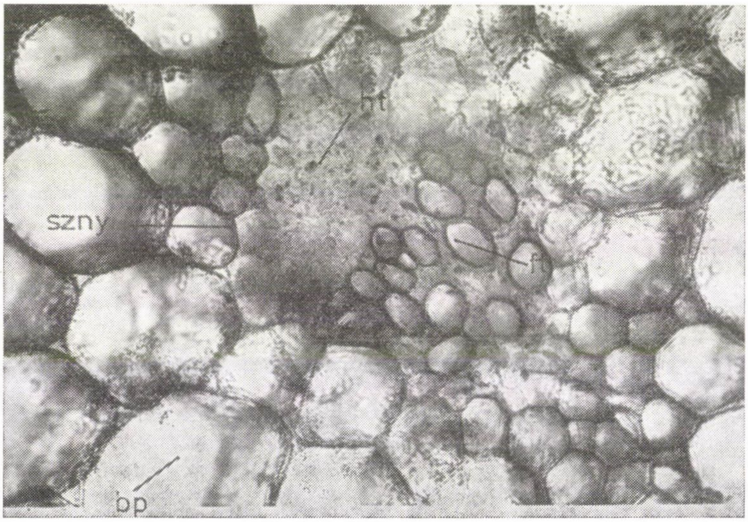


Fig. 2c

Fig. 2. ***Dactylorhiza maculata.*** *a* — Detail of the lower leaf epidermis (10× obj., 3.5× oc.); *b* — Detail of the upper leaf epidermis (10× obj., 3.5× oc.); *c* — Cross-section detail of stem (25× obj., 3.5× oc.). ht=phloem, ft=xylem, szny=vascular bundle, bp=medullar parenchyma

Stem. The epidermis cells show a slight radial elongation, and their outer tangential walls have a thick cuticle. There are stomata between the epidermis cells. The round or irregular parenchymatous cells of the chlorenchyma are arranged in 4—5 rows. The cells are rich in chloroplasts; there are a great many intercellular spaces. In this chlorenchyma layer leaf trace bundles appear. In the central cylinder the sclerenchyma tissue consists of 4—5 rows of cells with slightly lignified walls. The smaller vascular bundles adjoin the sclerenchyma ring. Towards the interior of the stem the larger, closed collateral vascular bundles show a scattered arrangement, with a large proportion of phloem. No sclerenchyma cap is found. The medullar cells are large, and breaks are found towards the base of the stem (Fig. 2*c*).

Gymnadenia conopea (L.) R. Br. et Ait.

Leaf. The cells of the lower epidermis are relatively small; their outer tangential walls have a cuticle. The cell-walls are straight or slightly curved. The average size of the cells is 61.9 $\mu \times 99.6$ μ. The number of epidermis cells is 32.60/mm^2. There are numerous stomata, round or oval in shape, with an average size of 49.8 $\mu \times 61.8$ μ. The number of stomata is 10.78/mm^2. The stoma index is 24.85 (Fig. 3*a*).

In the upper epidermis the cells are larger than in the lower one, 91.8 $\mu \times 128.0$ μ on average. The cell-walls are slightly curved with a thick cuticle over the outer tangential walls. There are very few stomata; they are rounded in shape and have an average size of 50.4 $\mu \times$ 57.6 μ. The number of epidermis cells is 18.35/mm^2, and the number of stomata 2.7/mm^2. The stoma index is 11.0.

The parenchyma tissue is 4—5 cell-rows thick towards the edges of the leaf, and consists of 8—10 cell-rows in the middle. The cells contain few chloroplasts; there is a fairly large number of intercellular spaces between the cells. Cells containing raphid also occur. According to Camus, towards the bottom of the middle vascular bundles collenchyma develops, though this has not been found in the Hungarian examples.

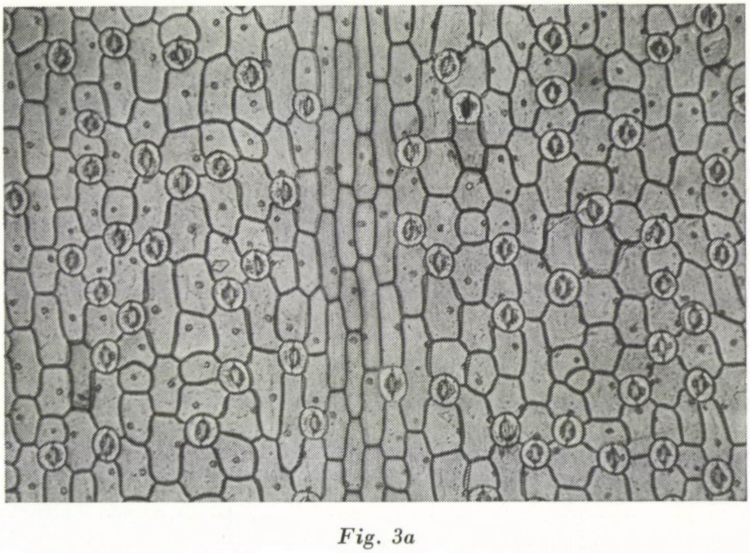


Fig. 3a

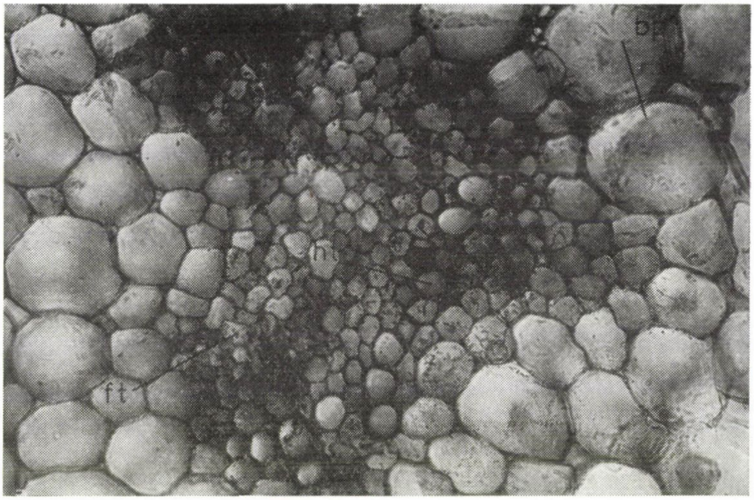


Fig. 3b

Fig. 3. ***Gymnadenia conopea.*** ***a*** — Detail of the lower leaf epidermis (10× obj., 3.5× oc.); ***b*** — Cross-section detail of stem (25× obj., 3.5× oc.). ht = phloem, ft = xylem, bp = medullar parenchyma

Stem. The epidermis cells are thickly cuticled with many stomata between the cells. The chlorenchyma is 3—4 cell-rows thick with intercellular spaces between the cells. The scelerenchyma ring is formed by 4—6 rows of cells with highly lignified walls. In this layer closed collateral vascular bundles are found. In the parenchymatous stele ground tissue there is a layer 4—5 cell-rows thick with highly lignified walls adjacent to the sclerenchyma ring. A scattering of closed collateral vascular bundles are found here; a sclerenchyma cap develops above the phloem (Fig. 3*b*).

Ophrys sphegodes Mill.

Leaf. The walls of the lower epidermis cells are slightly curved; a large number of stomata develop here (no data are available on their size). The cells of the upper epidermis are longish and the walls are straight. Their average size is 97.7 $\mu \times 150.8\ \mu$. There are no stomata. The number of epidermis cells is 11.95/mm^2 on average (Fig. 4*a*).

The parenchymatous layer is a tissue 3—6 cell-rows thick, rich in chloroplasts, in which there are closed collateral vascular bundles. Raphid-containing cells are very rare.

Stem. The cross-section shows an unribbed circle. The outer wall of the epidermis, which is formed by a single cell-row, has a thin cuticle; there are few stomata between the cells. The chlorenchyma tissue consists of two cell-rows with smaller or larger intercellular spaces between the cells. Within the chlorenchyma a sclerenchyma ring 3—5 cell-rows thick, consisting of highly lignified cells, is found. It is adjoined by a group of closed collateral vascular bundles arranged in the form of an outer circle. Among the larger or smaller polygonal or rounded cells of the parenchymatous stele ground tissue vascular bundles are found, again arranged in a circle. They have a large phloem and a comparatively small xylem. Thus, the vascular bundles are arranged in two concentric circles. The medulla is large without cavities (Fig. 4*b*).

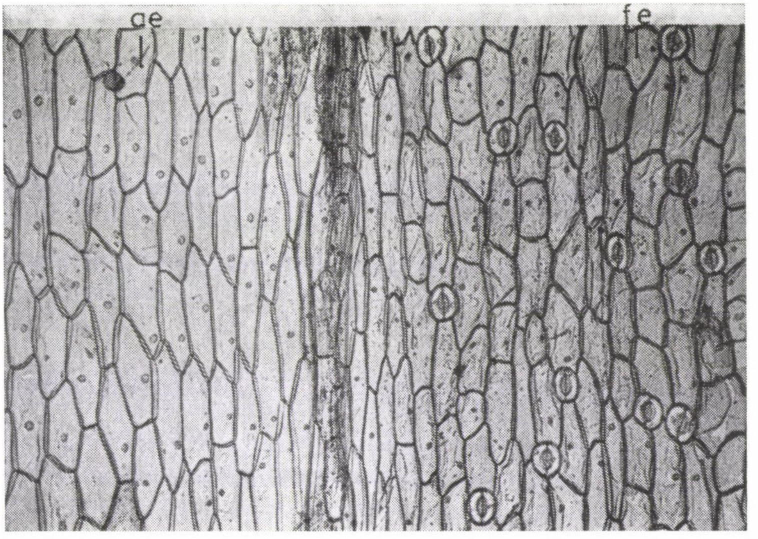


Fig. 4a

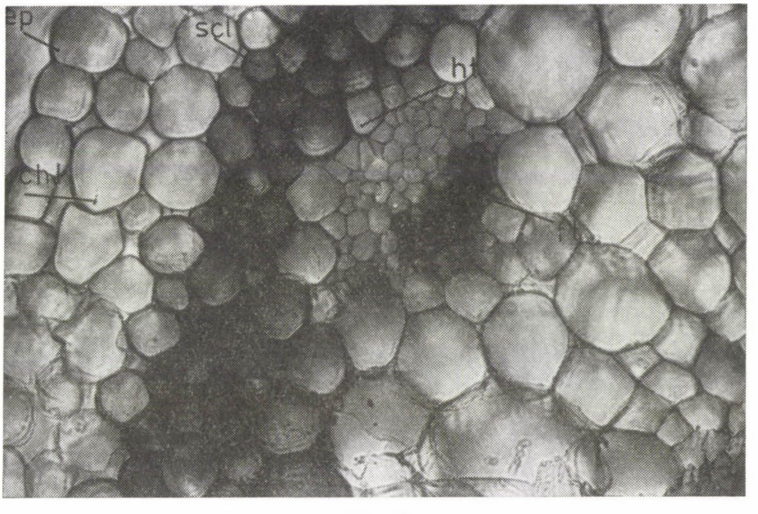


Fig. 4b

Fig. 4. ***Ophrys sphegodes.*** *a* — Detail of leaf epidermis (10× obj., 3.5× oc.): ae. = **lower epidermis**, fe. = upper epidermis; *b* — Cross-section detail of stem (25× obj., 3.5× **oc.**). **ep** = epidermis, chl = chlorenchyma, scl = sclerenchyma, ht = phloem, ft = **xylem**

Orchis coriophora L.

Leaf. The cells of the lower epidermis are highly elongated parallel to the longitudinal axis of the leaf. The cell-walls are straight; the average size of the cells is 65.4 $\mu\times$ **295.8** μ. The average number of epidermis cells is 14.65/mm^2. The stomata are oval with an average size of 57.6 $\mu\times$ 72.0 μ. The number of stomata is 4.8/mm^2; the stoma index is 24.67 (Fig. 5*a*).

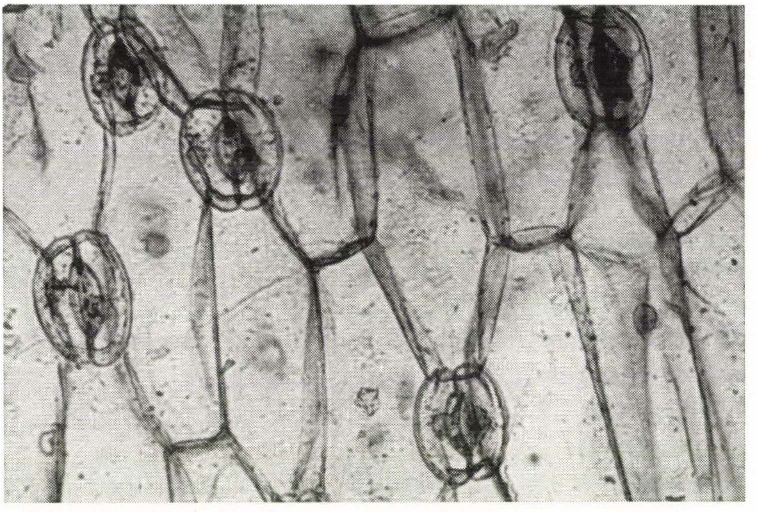


Fig. 5a

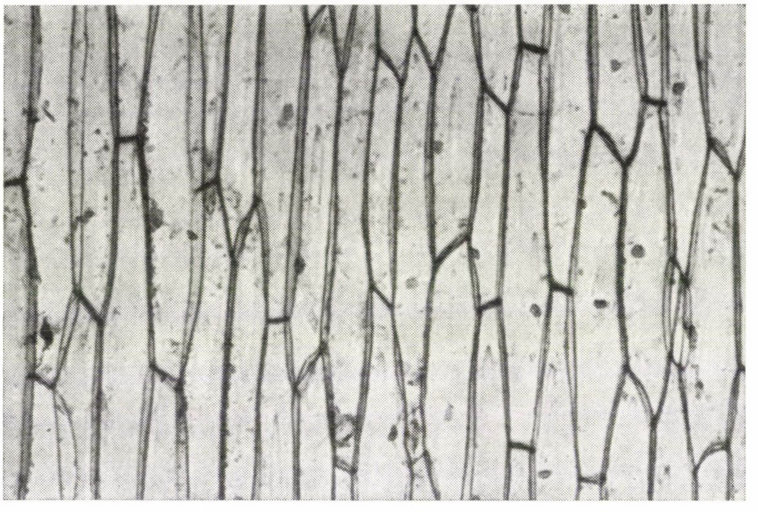


Fig. 5b

Fig. 5. Orchis coriophora. a — Detail of the lower leaf epidermis (10× obj., 10× oc.); *b* — Detail of the upper leaf epidermis (10× obj., 3.5× oc.)

In the upper epidermis the cells are large and very long, their walls are straight or slightly curved. The average size is 66.4 $\mu \times 413.5$ μ. The oval stomata, which are scattered, have an average size of 47.28 $\mu \times 73.4$ μ. The number of epidermis cells is 10.27/mm^2, and the number of stomata 0.58/mm^2. The stoma index is 5.34 (Fig. 5*b*).

The mesophyllum consists of 5—8 rows of cells rich in chloroplasts. Many of the cells contain raphid.

Stem. The slightly cuticled cells of the epidermis are quite large with few stomata between them. The chlorenchyma is only 1—2 cell-rows thick, with a considerable amount of intercellular space between the cells. Within the chlorenchyma, towards the centre of the stem, a sclerenchyma layer 4—5 cell-rows thick is found, in which there are smaller closed collateral vascular bundles. The cells of the parenchymatous stele ground tissue have highly lignified walls; the cells of the inner rows are larger than those in the outer rows. The majority of the collateral vascular bundles are found in this tissue, again arranged in a circle. The vascular bundles have a sclerenchyma cap consisting of only a few cells. The parenchyma cells of the medulla are large with a great deal of intercellular space between them; in the middle of the stem there are breaks in the medulla and large cavities are formed.

Orchis laxiflora Lam. ssp. **palustris** (Jacq.) A. et G.

Leaf. The cells of the lower epidermis are elongated in the direction of the longitudinal axis of the leaf; the cell-walls are straight or curved. The average size of the cells is $48.0\ \mu \times 146.2\ \mu$. The number of epidermis cells is $25.27/\text{mm}^2$ on average. The stomata are roundish or slightly oval; their average size is $41.2\ \mu \times 56.2\ \mu$. The number of stomata is $10.19/\text{mm}^2$ (Fig. 6*a*).

In the upper epidermis the cells are much larger than in the lower one, and very elongated. Their average size is $63.2\ \mu \times 192.0\ \mu$. The cell-walls are straight or curved; there are no stomata between the cells. The number of epidermis cells is $17.60/\text{mm}^2$ (Fig. 6*b*).

The mesophyllum is a rather thick layer, consisting of 8—10 cell-rows in the middle and 4—6 cell-rows towards the edges of the leaf. The cells are of irregular shape and abound in chloroplasts.

Stem. The epidermis cells are small, slightly cuticled, with a great many stomata between them. Below the epidermis (in cross-section) there is a fairly thick (6—8 cell-rows) chlorenchyma layer rich in chloroplasts. The cells in this layer are medium large, polygonal or rounded, with few intercellular spaces between them. The leaf trace bundles found in this layer are surrounded by a bundle sheath. There is a sclerenchyma cap above the phloem of the bundles.

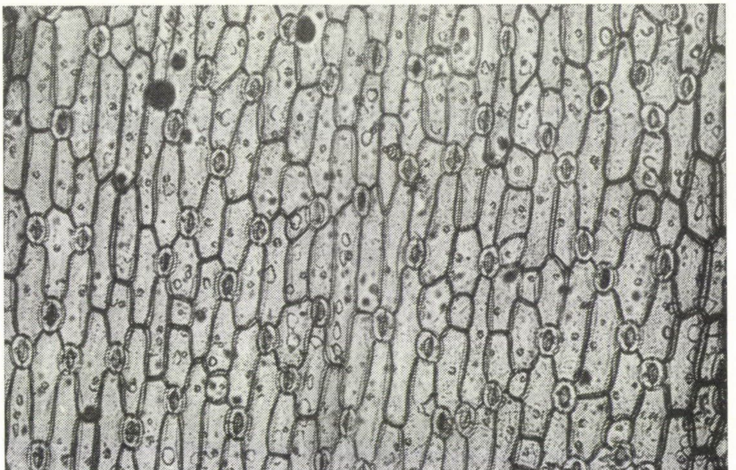


Fig. 6a

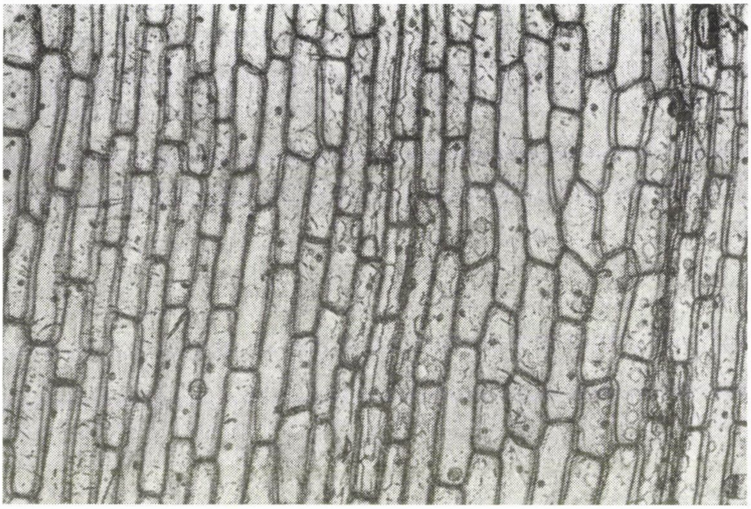


Fig. 6b

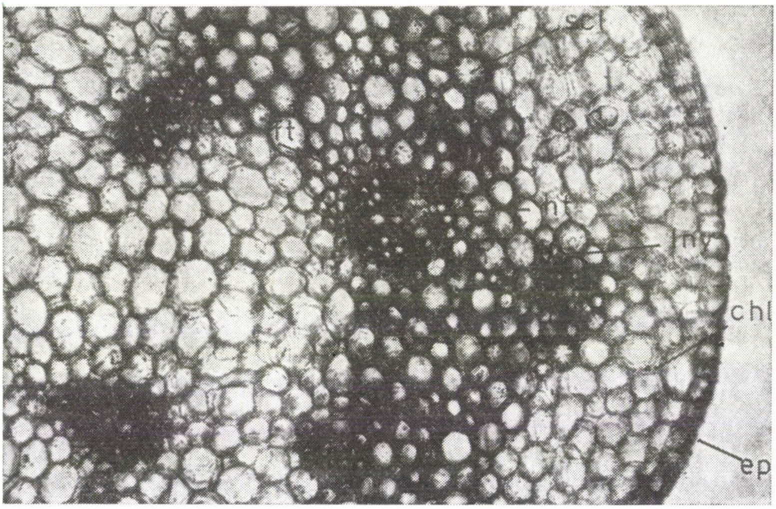


Fig. 6c

Fig. 6. ***Orchis laxiflora*** **ssp.** ***palustris.*** ***a*** — Detail of the lower leaf epidermis (10× obj., 3.5× oc.); *b* — Detail of the upper leaf epidermis (10× obj., 3.5× oc.); *c* — Cross-section detail of stem (10× obj., 3.5× oc.). ep = epidermis, chl = chlorenchyma, lny = leaf trace bundle, scl = sclerenchyma ring, ht = phloem, ft = xylem

In the sclerenchyma ring, which consists of 8—9 rows of considerably thickened cells, smaller vascular bundles are found with a sclerenchyma cap composed of a few cells. The vascular bundles which are found in a scattered arrangement towards the interior of the stem are also supplied with sclerenchyma caps. The phloem of these vascular bundles is larger than the xylem. The medulla fills up the centre of the stem (Fig. 6*c*).

Orchis militaris L.

Leaf. The cells of the lower epidermis are of medium size (88.8 $\mu \times$ 131.8 μ on average), somewhat elongated, with slightly curved walls. The number of epidermis cells is 16.25/mm^2. The stomata are round; their average size is 47.8 $\mu \times$ 48.0 μ. The average number of stomata is 7.07/mm^2. The stoma index is 30.31.

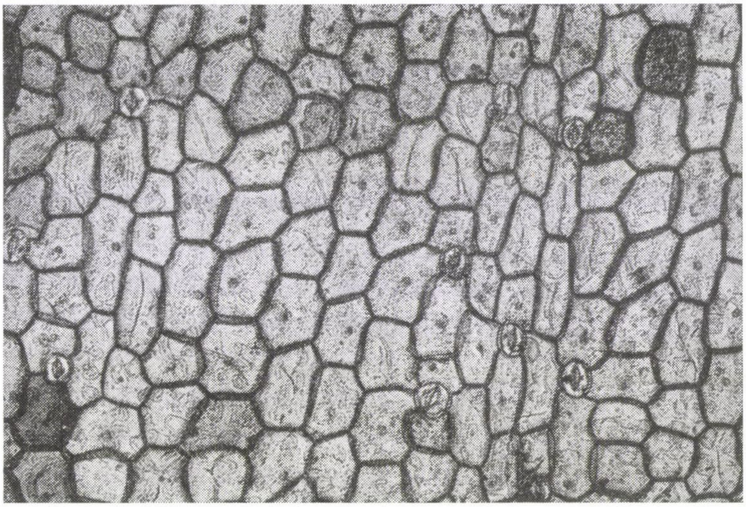


Fig. 7a

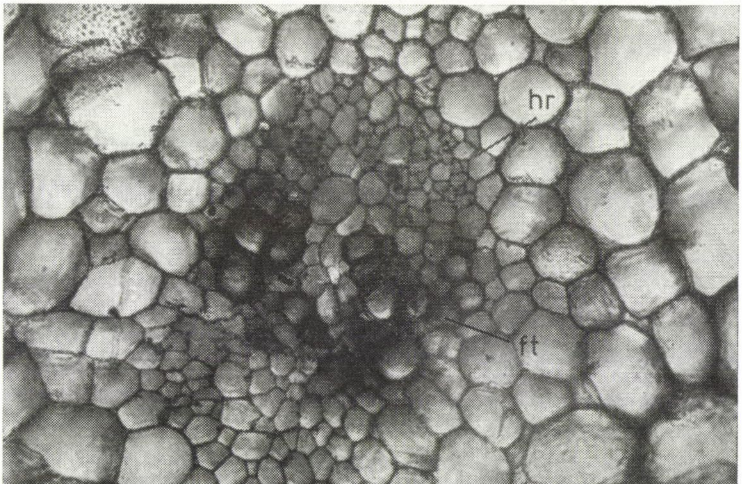


Fig. 7b

Fig. 7. *Orchis militaris*. *a* — Detail of the upper leaf epidermis (10$\times$ obj., 3.5$\times$ oc.); *b* — Cross-section detail of stem (25$\times$ obj., 3.5$\times$ oc.) with a vascular bundle. ft = xylem, ht = phloem

In the upper epidermis the cells are only slightly smaller than in the lower one; their average size is 79.8 $\mu\times$127.8 μ. The cell-walls are moderately curved. The stomata are very few in number, of round shape, with an average size of 58.2 $\mu\times$62.4 μ. The average number of epidermis cells is 17.51/mm^2, and that of the stomata 1.85/mm^2. The stoma index is 9.55 (Fig. 7*a*).

Towards the middle of the leaf the mesophyllum generally consists of 8—10 cell-rows; there is a great deal of intercellular space between the parenchymatous cells. This parenchymatous tissue becomes thinner towards the edges of the leaf. The closed collateral vascular bundles are found in this tissue.

Stem. In cross-section the costate stalk shows an undulating border line. The epidermis cells are large; their outer tangential walls have a thick cuticle with many stomata between the cells. The chlorenchyma consists of 3—4 rows of small rounded cells with a lot of intercellular space between them. Within this (towards the centre of the stem) 2—3 rows of sclerenchyma cells with slightly lignified walls are found. Then the stele ground tissue, composed of round-walled or polygonal parenchyma cells, follows, after which, towards the interior, comes the parenchymatous medulla with its larger cells. In cross-section the closed collateral vascular bundles in the stele ground tissue are arranged in a single circle. The medulla has breaks in it (Fig. 7*b*).

At the sites where the vascular bundles of the leaf enter the stem (or those of the stem branch off towards the leaf), at the levels of the nodes, scattered leaf trace bundles appear in the chlorenchyma under the epidermis. The sclerenchyma layer is thicker (it may consist of up to 4—5 cell-rows), and the vascular bundles show a scattered arrangement. The medulla fills up the inside of the stem.

Orchis pallens L.

Leaf. When viewed from above the cells of the lower epidermis are longish with curved walls. Their average size is 55.1 $\mu\times$154.6 μ. The number of epidermis cells is 26.0/mm^2. The oval stomata have an average size of 47.0 $\mu\times$62.4 μ. The average number of stomata is 9.1/mm^2, and the stoma index is 2.5.

The cells of the upper epidermis are shorter, hexagonal and have straight walls. Their average size is 120.0 $\mu\times$166.8 μ. There are no stomata. The number of epidermis cells is 12.7/mm^2.

Stem. The epidermis cells are thickly cuticled with stomata between them. The chlorenchyma tissue consists of 3—4 rows of round cells with a great deal of intercellular space between them. The sclerenchymatous ring is made up of only two rows of cells, the walls of which are only slightly lignified. In the parenchymatous ground tissue of the stele the closed collateral vascular bundles are arranged in a circle. The vascular bundles have no sclerenchyma caps. The medulla is large, and a great deal of intercellular space is found between its parenchymatous cells.

Orchis purpurea Huds.

Leaf. The lower epidermis cells are large and longish. Their average size is 74.4 $\mu\times$ 162.0 μ. The cell-walls are straight, or at most slightly curved. The number of cells is 16.25/mm^2. The stomata are roundish or somewhat oval with an average size of 57.4 $\mu\times$ 62.2 μ. The number of stomata is 6.99/mm^2, and the stoma index is 30.07. The epidermis is thinly covered with unicellular hyaline hairs (Fig. 8*a*).

In the upper epidermis the cells are smaller and not as long as those in the lower one. Their average size is 89.2 $\mu\times$143.2 μ. The cell-walls are straight and there are no stomata. The number of epidermis cells is 15.47/mm^2 on average (Fig. 8*b*).

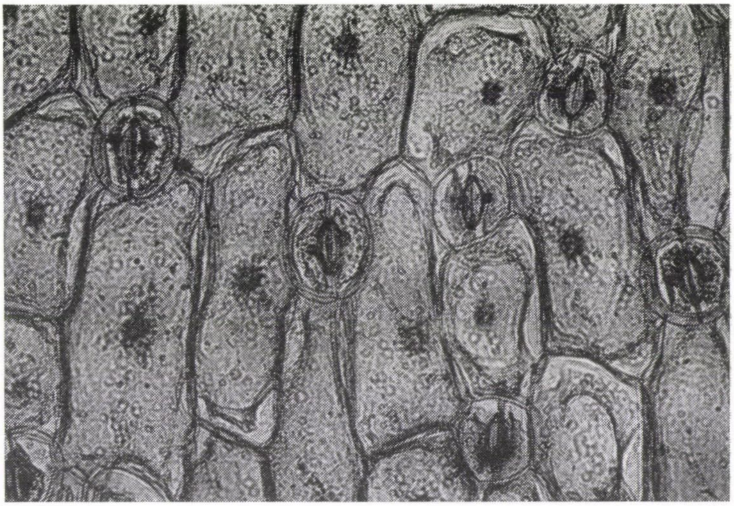


Fig. 8a

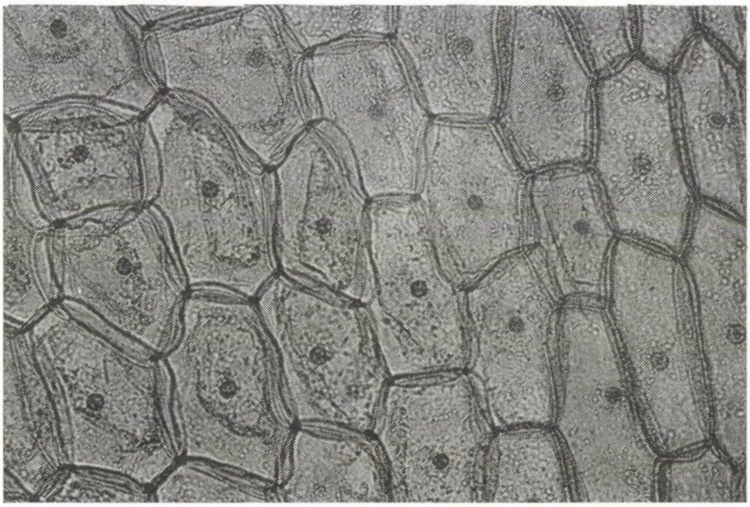


Fig. 8b

***Fig. 8.** Orchis purpurea. a* — Detail of the upper leaf epidermis (25× obj., 3.5× oc.); *b* — Detail of the lower leaf epidermis (25× obj., 3.5× oc.)

The mesophyllum is 6—8 cell-rows thick; there is a great deal of intercellular space between its parenchymatous cells. Many of the cells contain raphid.

Stem. Between the cuticled epidermis cells few stomata are found. The chlorenchymatous tissue consists of 3 cell-rows. The cells are small and polygonal, with a great deal of intercellular space between them. The sclerenchymatous tissue is about 4 cell-rows thick, the cell-walls are only slightly lignified. The latter is adjoined (towards the centre) by the closed collateral vascular bundles, arranged roughly in a circle. The phloem is well developed; it has no sclerenchyma cap. There are no scattered vascular bundles towards the centre of the stem. There are no breaks in the medulla; it consists only of parenchymatous cells separated by the intercellular space.

Plantanthera bifolia (L.) Rchb.

Leaf. The lower epidermis cells are large and highly elongated with straight or slightly curved walls. Their average size is $79.2\ \mu\times 214.2\ \mu$, so the number of cells per mm^2 is small, 10.02 on average. The stomata are oval, or slightly oval; their average size is $61.2\ \mu\times 76.0\ \mu$. The average number of stomata is $2.61/mm^2$; the stoma index is 20.66 (Fig. 9*a*).

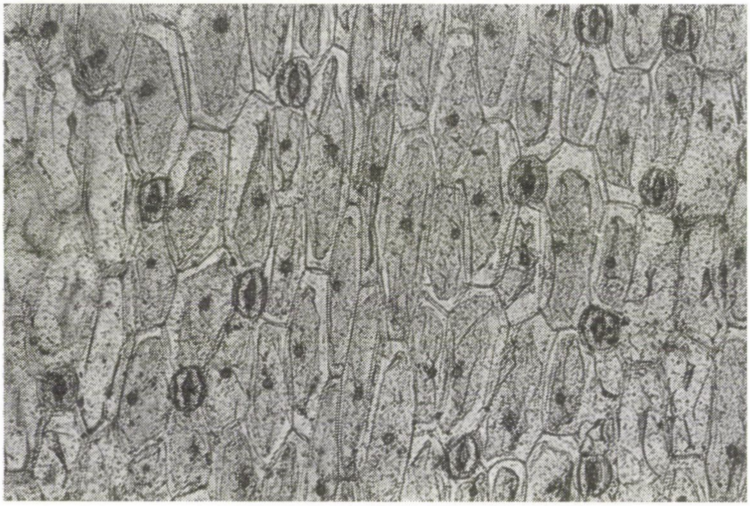


Fig. 9a

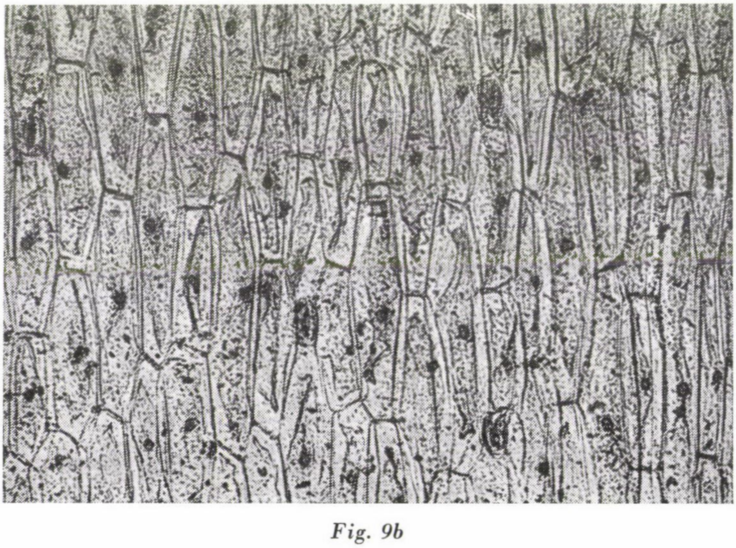


Fig. 9b

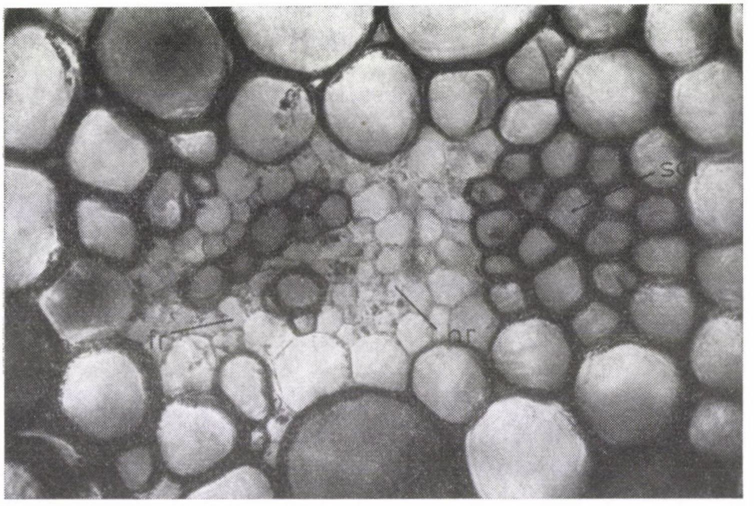


Fig. 9c

Fig. 9. Platanthera bifolia. a — Detail of the upper leaf epidermis (10× obj., 3.5× oc.); *b* — Detail of the lower leaf epidermis (10× obj., 3.5× oc.); *c* — Cross-section detail of stem (25× obj., 3.5× oc.). scl = sclerenchyma cap, ht = phloem, ft = xylem

The cells of the upper epidermis are highly elongated, large and straight-walled. Their average size is 74.1 $\mu \times 327.5$ μ. The oval stomata are widely scattered and have an average size of 53.8 $\mu \times 79.0$ μ. The stoma index is 0.45. The average of epidermis cells is 9.26/mm^2 and that of the stomata 0.04/mm^2 (Fig. 9*b*).

The mesophyllum is made up of parenchymatous tissue consisting of 7—10 rows of transversally elongated cells, in which there are collateral vascular bundles. There are a few raphid-containing cells too.

Stem. This is heavily ribbed. There are a great many stomata between the slightly cuticled epidermis cells. The chlorenchyma consists of 6—7 rows of cells which are mostly rounded or irregular. Leaf trace bundles are found in this tissue. Towards the centre of the stem this is followed by 4 rows of sclerenchymatous cells with somewhat lignified walls, adjoined by some of the vascular bundles which show a circular arrangement in cross-section. The closed collateral vascular bundles have a very thick sclerenchyma-cap above the phloem connected with the sclerenchymatous layer. The other vascular bundles are scattered in the stele ground tissue, again with a sclerenchyma cap over the phloem. The xylem is fairly small, while the phloem occupies the larger part of the vascular bundle. There are no breaks in the parenchymatous cells of the medulla, and no cavities in the pith (Fig. 9*c*).

Cypripedilum calceolus L.

Stem. This is ribbed. The tangential wall of the epidermis is covered by a thick cuticle; the cells are small. Multicellular hairs cover the epidermis (Fig. 10*a*). The chlorenchyma is 5—6 cell-rows thick; the cells are irregular with a greater or lesser amount of intercellular space between them. Within this chlorenchyma, roughly in a circle, some of the collateral vascular bundles are found, while the other vascular bundles are scattered in the stele ground tissue

Fig. 10a

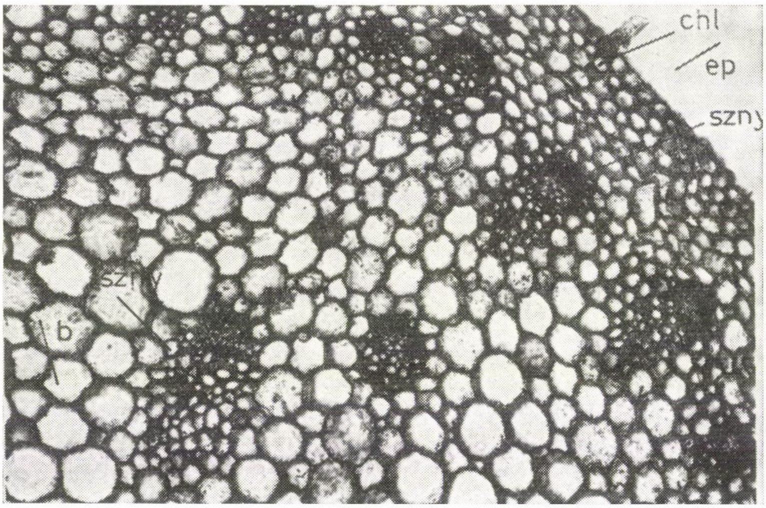


Fig. 10b

(**Fig. 10*b***). In the vascular bundles the xylem is larger than the phloem. The presence of a cap consisting of sclerenchymatous cells with highly lignified walls above the phloem is very characteristic (Fig. 10*c*). In the medulla there are no breaks in the parenchymatous cells.

Cephalanthera Damasonium (Mill.) Druce

Stem. The presence of ribs and striae results in an undulating cross-section. The outer tangential walls of the epidermis cells are thickly cuticled; the cells are regular squares, or at most somewhat rounded-off at the corners. The presence of emergences is typical. The chloren-

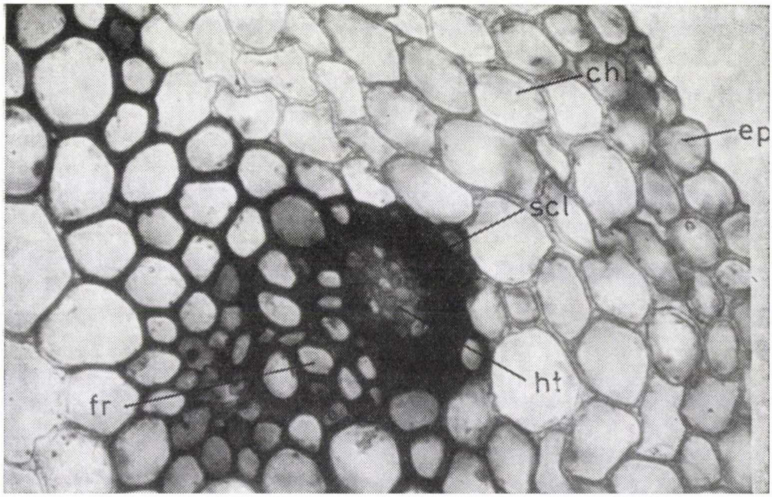


Fig. 10c

Fig. 10. *Cypripedilum calceolus. a* — Multicellular hair on the stem (cross-section, 25× obj., 10× oc.); *b* — Cross-section detail of stem (10× obj., 3.5× oc.). ep = epidermis, **chl** = chlorenchyma, szny = vascular bundle; *c* — same as *b* (10× obj., 10× oc.)

chyma is 7—9 cell-rows thick. Its cells are large and irregularly rounded-off, with **intercellular space** between them. The sclerenchymatous layer is made up of 3—4 rows of highly **lignified cells.** The smaller collateral closed vascular bundles are found in this layer, forming **a rough circle** in cross-section. The vascular bundles have a highly lignified sclerenchyma **cap above the phloem.** Towards the centre of the stem, in the stele ground tissue or in the **medullar**

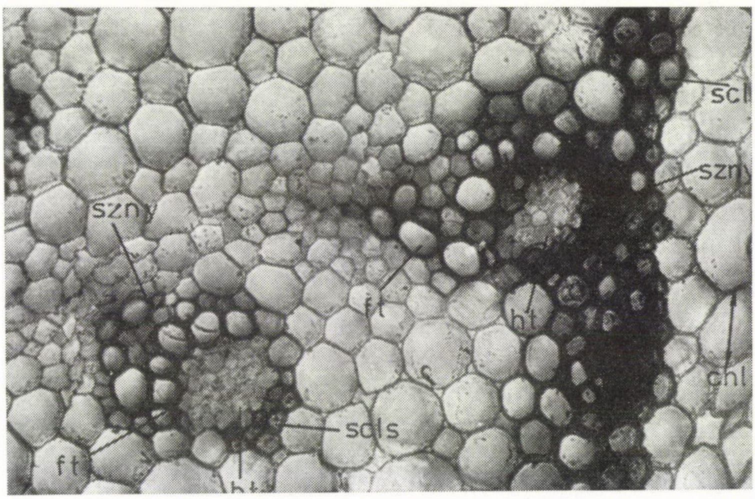


Fig. 11. ***Cephalanthera Damasonium.*** Cross-section detail of stem (25× obj., 3.5× **oc.**). **chl** = chlorenchyma, scl = sclerenchyma ring, scls = sclerenchyma cap, ht = **phloem,** ft = xylem

parenchyma, the larger vascular bundles are found in a scattered arrangement. The phloem and xylem of the bundles are equally well developed. The phloem is covered by a sclerenchyma cap. There is a great deal of intercellular space between the cells of the medullar parenchyma, but there are no breaks in the cells (Fig. 11).

Cephalanthera longifolia (Huds.) Fritsch

The cross-section of the stem is very similar to that in C. Damasonium. The epidermis cells are small, and their outer tangential walls are covered by a thick cuticle; here and there emergences can be observed. The large, irregular cells of the chlorenchyma are arranged in 7—8 rows. Within this, in cross-section, is found the highly lignified sclerenchyma ring which is 2—3 cell-rows thick but which becomes wider above the vascular bundles. Practically imbedded in this ring are found the smaller vascular bundles, set close to one another. Above the phloem of the bundles a sclerenchyma cap develops. The other vascular bundles are larger and scattered. Here, too, the well developed sclerenchyma cap above the phloem is apparent. The medulla forms a continuous parenchymatous tissue (Fig. 12).

Cephalanthera rubra (L.) Rich.

The stem has an undulating cross-section. The epidermis cells are small; their outer tangential walls are thickly cuticled, and there are stomata between the cells. On the upper part of the stem glandular hairs are found, but there are no emergences. Under the epidermis the chlorenchyma is very thick, consisting of 11—12 cell-rows; on the side facing the epidermis the cells are larger and irregular, while towards the centre they gradually become smaller and rounded-off. The sclerenchymatous rings is about 3 cell-rows thick. The smaller vascular bundles are placed quite thickly in it. Within this, the other, larger vascular bundles show

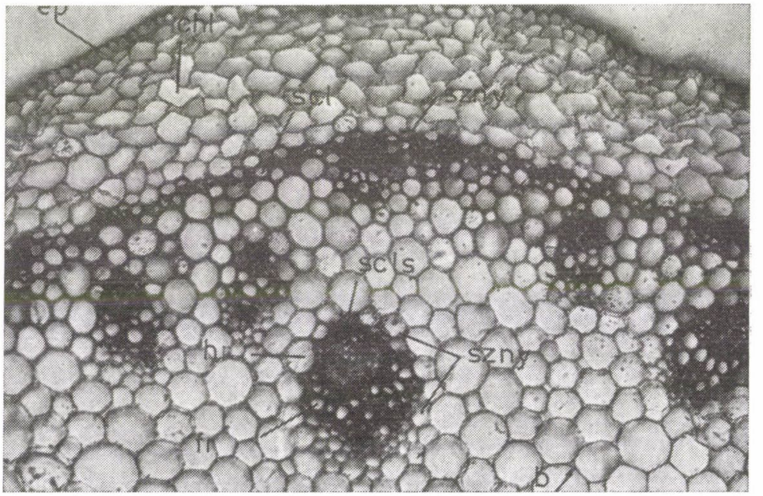


Fig. 12. Cephalanthera longifolia. Cross-section detail of stem (10× obj., 3.5× oc.). ep = epidermis, chl = chlorenchyma, scl = sclerenchyma ring, sclc = sclerenchyma cap, ht = phloem, ft = xylem, b = medusla

a scattered arrangement, and are surrounded by a well developed phloem crown and a sclerenchyma cap or sclerenchyma ring. The parenchymatous cells of the medulla are continuous, without any breaks.

Acknowledgements

Thanks are expressed to Mrs. Julia Zotter for the preparation of the microscope slides, and for her thoughtful and precise work in microscope measurements.

*

Prepared at the Botanical Gardens of the Eötvös Loránd University, Budapest.

O. Sz. Borsos

References

Borsos, O. (1952/54): Magyarország és a Kárpát-medence orchideáinak geobotanikai monográfiája. I. (Geobotanical monograph of orchids in Hungary and the Carpathian basin. I.). Annales Biol. Univ. Hung., **2**, 183—192.

Borsos, O. (1959): Geobotanische Monographie der Orchideen der pannonischen und karpatischen Flora. II. Annal. Univ. Budapest., Sect. Biol., **2**, 59—93.

Borsos, O. (1960): Geobotanische Monographie der Orchideen der pannonischen und karpatischen Flora. IV. Annal. Univ. Budapest., Sect. Biol., **3**, 93—129.

Borsos, O. (1961): Geobotanische Monographie der Orchideen der pannonischen und karpatischen Flora. V. Annal. Univ. Budapest., Sect. Biol., **4**, 51—82.

Borsos, O. (1962): Geobotanische Monographie der Orchideen der pannonischen und karpatischen Flora. VI. Annal. Univ. Budapest., Sect. Biol., **5**, 27—61.

Borsos, O. (1963): Geobotanische Monographie der Orchideen der pannonischen und karpatischen Flora. VII. Annal. Univ. Budapest., Sect. Biol., **6**, 43—81.

Borsos, O. (1964): Geobotanische Monographie der Orchideen der pannonischen und karpatischen Flora. VIII. Annal. Univ. Budapest., Sect. Biol., **7**, 45—71.

Borsos, O. (1966): Geobotanische Monographie der Orchideen der pannonischen und karpatischen Flora. X. Annal. Univ. Budapest., Sect. Biol., **8**, 71—86.

Borsos, O.—Soó, R. (1966): Geobotanische Monographie der Orchideen der pannonischen und karpatischen Flora. IX. Annal. Univ. Budapest., Sect. Biol., **8**, 315—336.

Camus, H. C. (1928): Iconographie des Orchidées d'Europe. Ed. Paul Lechevalier, Paris.

Esau, K. (1969): Pflanzenanatomie. Fischer Verl. Stuttgart.

Kohl, A. (1899): Raphidenzellen. Bot. Centralbl., **79**, 273—282 + Taf. IV—V.

Metcalfe, C. R. (1960): Anatomy of the monocotyledons. University Press. Oxford.

Sárkány, S.—Szalai, I. (1964): Növényszervezettani gyakorlatok. Növénytani Praktikum. I. (Plant organization exercises. Botanical practice. I.). Ed. 2. Tankönyvkiadó, Budapest.

Solereder, H.—Meyer, F. J. (1930): Systematische Anatomie der Monocotyledonen. VI. Scitamineae-Microspermae. Verlag von Gebrüder Borntraeger. Berlin, 92—242.

Újhelyi, J. (1954): Újabb eljárás a szálaslevelű egyszikűek, különösen a Gramineae család epidermisz-szövettani vizsgálatához (A new method of histological examination of epidermis in linear-leaved monocotyledons, particularly in the family Gramineae). Bot. Közl., **45**, 227—230.

Ziegenspeck, H. (1936): Orchideaceae, in: Kirchner—Loew—Schröter: Lebensgeschichte der Blütenpflanzen Mitteleuropas. I./4. Verlagsbuchhandlung Eugen Ulmer, Stuttgart.

METHOD FOR STUDYING THE STRUCTURE OF THE YIELD AVERAGE

As a simple approach the yield average can be regarded as a complex of meteorological, agrotechnical and soil effects. In agricultural research, farm production and planning it is very important to know the extent to which these basic factors determine the yield average, and the degree of yield fluctuation they are likely to cause. An assessment of quantitative ratios is obviously required.

We have elaborated an analytical model by means of which, with certain reservations and provided the necessary conditions are fulfilled, an approximate quantitative breakdown of a given yield average can be carried out even if only yield data are available. The basic principles of the model, the particulars of the calculation process and the results of the actual analyses carried out so far are presented below.

Since theoretical details of the method, including calculations, have already been published (ERDŐS 1976) it is described here in an abbreviated form, but with the addition of further development in some details.

1. *The structure of the yield average and the basic environmental factors*

The yield is the final result of plant growth which varies, as the combination of basic environmental factors changes, within wide limits both in space and time. A distinction is made between biological and economic yields. By biological yield the total (living or dry) mass of the plant is understood. The economic yield is the economically valuable portion (e.g. grain, tuber, berry, etc.) of the total plant mass, which serves the purpose of production. In this paper yield will always indicate the economic yield.

The plant assimilates the environmental conditions. In this process the ecological factors cannot replace each other, nor do they exert equivalent effects on the growth and development of the plants (biological laws). The environmental factors (material and energy) have biochemically determined shares in the yield. Consequently, any elementary mass unit of the yield average is the result of the joint complex action of all the basic environmental factors present. On the other hand, it is also a well-known fact that the proportions of the main components in the fresh crop (carbohydrates, proteins and water) may vary between rather wide limits and the environmental factors play a decisive role in this. To break down the yield in a biological sense thus involves a procedure quite different from what will be discussed here. The breakdown of the yield average in the present use of the term has an "idealised" rather than a biological meaning. That is, the change (increase or fluctuation) in the yield is equivalent to, or closely related with changes in certain environmental factors and can thus be attributed to the action of the factors concerned. The result of such an idealised breakdown might well be a useful starting-point for the solution of many problems.

The meaning of the three complex factors (factor groups) which shape the yield average must also be defined. In such a simple breakdown there is no need to examine the inner structure of the individual factor complexes in detail, to weight the components of the factors, to clarify the criteria of interactions or independence, etc. On the other hand, it is useful to define the basic factors and separate them from one another, so as to exclude the possibility of contradictions arising later.

The soil factor is fundamentally considered as a natural factor, as an indispensable but given precondition of production which does not change with time. It thus involves the genetic soil type with its major physico-chemical properties: the texture, to a certain extent the structure, whether it is deep or shallow layered, degree of leaching, water retention capacity, constant ground-water level, exposure, etc.

The agrotechnical factor includes, basically, everything that can be influenced by the farmer's activity: plant species and variety, cultivation method, and above all the nutrient level, irrigation, etc.

The meteorological factor includes the necessary conditions of plant life: heat, light, water and air. There are other, secondary meteorological factors which are only important in special cases, mostly due to their adverse effects (clouds, wind, contamination, etc.).

When studying the relation between the weather and the plant the active components of the weather must be considered. This is an agrometeorological concept and means the value (within a certain range of values and only in the plant or in its surroundings) of the meteorological elements which are essential to the plant and are known and proved to have a decisive influence on its growth and development. The term weather effect, on the other hand, means the yield response of the plant to the influence of the weather. Hereafter, M will thus indicate the active weather components (temperature, radiation, precipitation, etc.), and q(M) the result of weather effects (yield volume). Naturally a distinction in the interpretation of the active components and effect of the soil and agrotechnics in an analogous manner is also justified.

2. *Model for breaking down the yield average*

If the basic factors (meteorological, agrotechnical and soil factors) can be quantitatively expressed, then the yield can, in principle, be expressed in a correct mathematical form as some sort of function of the effects of the basic factors. In general

$$q = q(M, A, F) \tag{1}$$

where q is the yield, and M, A and F are the weather, agrotechnical and soil factors. The actual function of (1) is very difficult to produce, since the basic factors themselves are complex (and unknown) functions, and although we know that the environmental factors do not have equal weight in yield formation we do not know the actual "order of importance" of the different factors. If the latter were known, this alone would provide an a priori solution to the problem.

In the relevant literature a large number of yield functions representing partial approaches to (1) can be found. There are both empirical and theoretical attempts (Glenday 1955, Konstantinov 1966, 1976, Dmitrenko 1973, Sabanov 1973, Csáki *et al.* 1972, Mészáros—Csepregi 1972). The empirical methods usually involve the solution of simple regression equations, while the theoretical models consist of various complicated equations or equation systems. They all have the common feature of containing parameters that can only be determined from experimental material which expresses the environmental factors quantitatively.

The method described below helps in overcoming the difficulties outlined above and in breaking down the yield average to its basic factors to a good approximation. If the model is to be correctly applied the following conditions must be complied with:

1. In the case of a constant or steadily increasing level of agrotechnics the yearly fluctuations in yield are assumed to be exclusively due to the seasonal distribution and annual fluctuation of the climatic factors.

2. The trend of agrotechnical development within the time series of the yield data is assumed to be constant in time, and sudden short-term changes are taken as being uncharacteristic.

3. The "bumper yields" observed in the most favourable years are taken as being an approximation to the balanced optimum. The balanced yield optimum comes about when each basic factor has an optimum value.

The breakdown model suggested here is built up in the following way. Simple yield trends are calculated on the basis of yield data time series which are as long as possible. Methods for calculating trends can be found in the textbooks (e.g. Theiss 1958, Ezekiel—Fox 1970). A model for trend calculation is shown in Fig. 1. The trend function may be any monotonously increasing (and best fitting) elementary function, e.g. linear, power, logarithm function, etc.

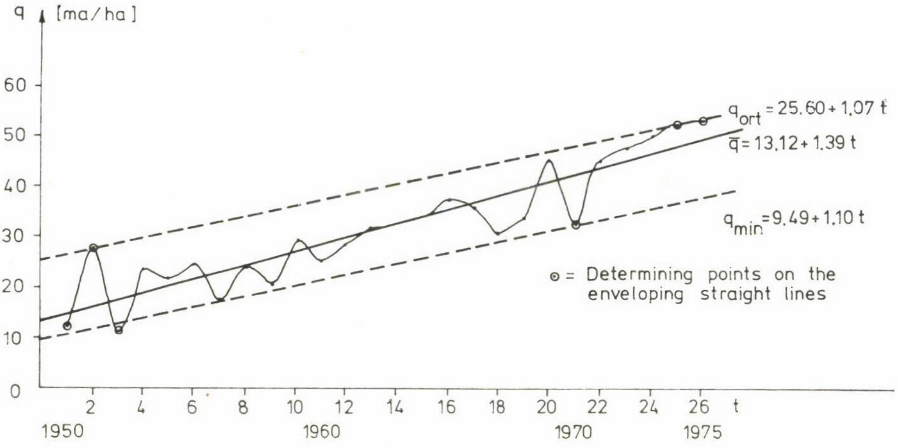


Fig. 1. Trend function for maize yield. Békés county, 1950—1975

In a linear case the trend function is:

$$\bar{q}(t) = q_0 + bt, \quad b > 0. \tag{2}$$

According to the usual interpretation of yield trends the $\bar{q}(t)$ trend function expresses the yield-increasing effect of agrotechnical development, assuming average weather conditions (by "average" weather conditions those which correspond more or less to the local climate are understood); the annual fluctuations of the actual yield $q(t)$ are caused by the annual fluctuations in the weather conditions; q_0 is the constant of the trend function, which contains the joint effect of the soil, "average" weather conditions and the initial level of agrotechnics (in unknown proportions).

In the next step the enveloping curves are determined. This can be done in two ways. First, the curve of function $\bar{q}(t)$ is shifted upwards or downwards so as to cover the point q_{max} (the highest yield observed) or q_{min} (the lowest yield observed). In this way two new functions are obtained: $q_{opt}(t)$ and $q_{min}(t)$. It is self-evident that in this case $\bar{q}(t)$ and $q_{opt}(t)$ or $q_{min}(t)$ are functions of identical type which differ only in the value of q_0. The other possibility is to visually choose some prominent q_{max} points and to calculate the fitted curve, $q_{opt}(t)$, for these independently of $\bar{q}(t)$. The function $q_{min}(t)$ is determined in a similar way. In this case $\bar{q}(t)$ and $q_{opt}(t)$ or $q_{min}(t)$ are not necessarily functions of the same type. In practice it is better to determine the enveloping functions in the latter way; the former method is only chosen when it is impossible to use the latter.

Below, general assumptions and considerations are presented point by point, on the basis of which, after the above calculations have been completed, the yield, as the resultant of the three basic factors, can be broken down in various combinations.

1. The joint effect of the three basic factors determines, in some way, the whole yield, that is,

$$q = q(M) + q(A) + q(F). \tag{3}$$

In Eq. (3) q, q(M), . . . are absolute yield quantities. If both sides of Eq. (3) are divided by q the relative values (proportions) which will be needed later are obtained:

$$q' = 1 = q'(M) + q'(A) + q'(F). \tag{4}$$

Before plant cultivation was begun (t_{00}), under natural conditions, the yield contained no agrotechnical effects, but was merely the result of soil and weather effects (as natural resources), that is,

$$q_{00} = q(\bar{M}) + q(F). \tag{5}$$

At an initial, low, primitive level of plant growing the yield is

$$q_k = q(\bar{M}) + q(A_k) + q(F). \tag{6}$$

The obvious conclusions are that if the level of cultivation approximates to the natural conditions, that is $q_k \to q_{00}$, then $q(A_k) \to 0$; at a very low level of cultivation $q(A_k)$ may be negligibly small compared to q(M) and q(F).

It often happens that we cannot or need not separate the effects of three basic factors, but only that of one of them, e.g. of the weather. In that case instead of Eq. (3) we can write

$$q = q(M) + q(A, F) \tag{7}$$

where q(A, F) expresses the joint action of soil and agrotechnics. Other combinations could be set up instead of Eq. (7).

Some related general conclusions are that if the proportions of two factors in the yield are determined either separately or together, the effect of the third factor, as the remaining member, is automatically given; the joint effect of two factors can always be determined more easily and more exactly than their separate effects, because the error due to interactions is eliminated; if on any grounds the effect of one factor is considered maximum, this is necessarily done more or less at the expense of another factor (or factors), since Eq. (3) is additive; it is also evident that the effects of all the factors cannot be simultaneously considered as maximum.

2. It is assumed that the weather can "contribute" as much to the yield in the most favourable year as it is able to "subtract" from the optimum yield in the least favourable year. Thus,

$$q(M)_{max} = q_{opt}(t_i) - q_{min}(t_i). \tag{8}$$

The function $q(M)_{max}$ will hereafter be called the full effect of weather fluctuation.

The weather contributes to any yield q by the extent to which $q(t_i) > q_{min}(t_i)$, that is,

$$q(M) = q(t_i) - q_{min}(t_i). \tag{9}$$

The function q(M) is called the effect of weather fluctuation, or the direct effect of the weather.

The yield-forming effect of average weather conditions is

$$q(\bar{M}) = \bar{q}(t) - q_{min}(t). \tag{10}$$

Function $q(\bar{M})$ is normally interpreted as the average value over several years, in which case the average over several years of the actual yield q(t) is nearly equal to $\bar{q}(t)$, the trend average.

A further concept, that of yield deficit due to the weather, is introduced in the following interpretation

$$H(M) = q_{opt}(t_i) - q(t_i). \tag{11}$$

H(M) represents the missing amount of yield "subtracted" from the optimum yield by the weather.

3. According to the classical interpretation of yield trends the approximate yield-forming effect of agrotechnical development can be expressed from a trend function of sufficient (but finite) length. E.g.:

$$q_1(A) = \bar{q}(t_i) - q_0. \tag{12}$$

If calculations are made for an "infinite" trend another approximate expression of the effect of agrotechnics is obtained:

$$q_2(A) = \bar{q}(t_i) - q_{00}. \tag{13}$$

The maximum effect of agrotechnics is obtained by the following formula:

$$q_3(A) = \bar{q}(t_i) - q(F), \tag{14}$$

in which $q(F)$ is the value substituted from Eq. (25).

Equations (12), (13) and (14) are various hypothetical estimates of the agrotechnical effect. In all three equations $\bar{q}(t_i)$ includes the effect of average weather conditions too. The average weather effect can be assumed to be strictly constant in time, which means that Eq. (13) expresses the actual agrotechnical effect because q_∞ also includes the average weather effect; in Eq. (12) $q_1(A)$ has a lower value than the actual agrotechnical effect, because q_0 includes not only the average weather effect but some agrotechnical effect too; $q_3(A)$ is definitely an overestimated value, because $q(F)$ is only a soil effect, that is, it does not contain either weather or agrotechnical effects. In practice, Eqs (13) and (14) are impossible to calculate, while $q_1(A)$ is easily obtained from any fairly long trend function. Difficulties are encountered, however, in applying the above equations for the separation of the weather effect, which has to be avoided. If the average weather effect, by contrast to the above assumption, is not strictly constant in time, then the interpretation of the above equations will also be uncertain.

For more than one reason it is useful to determine a certain minimum agrotechnical effect. Unlike the classical interpretation of yield trends the minimum effect of agrotechnics (compared to which the actual value must be higher) can be estimated from the following expressions:

$$q_4(A) = q_{min}(t_i) - q_0, \tag{15}$$

$$q_5(A) = q_{min}(t_i) - q_{00}, \tag{16}$$

$$q_6(A) = q_{min}(t_i) - q(F), \tag{17}$$

$$q_7(A) = q_{min}(t_i) - q(F)_{max}, \tag{18}$$

in which $q(F)$ is to be substituted from Eq. (25) and $q(F)_{max}$ from Eq. (24). A comparison of the above functions shows that

$$q_6(A) > q_7(A) > q_5(A) > q_4(A).$$

It is obvious from our interpretation of the model that $q_{min}(t_i)$ does not include weather effects. Accordingly, $q_6(A)$ is an actual estimate, and $q_7(A)$ an approximate actual estimate of the agrotechnical effect; $q_4(A)$ and $q_5(A)$ are underestimated values of the agrotechnical effect, since q_0 and q_{00} include average weather effects. In practice $q_5(A)$ and $q(_6A)$ are impossible to calculate, while the value of $q_4(A)$ can be obtained from any yield trend function, and that of $q_7(A)$ from any sufficiently long yield trend function. In the subsequent analysis the agrotechnical effect is always expressed, where possible, by Eq. (18).

4. The separation of the agrotechnical effect and the soil effect is, in fact, one and the same problem, if the weather effect has already been separated. As has been seen, the correct estimation of the soil effect is a precondition for the assessment of the actual agrotechnical effect.

According to the original definition the soil effect has to be determined as a constant. This can be approached in several ways:

a) The soil effect is taken to be the constant (q_0) from a trend function of definite length. It is known, however, that

$$q_0 > q(F), \tag{19}$$

because q_0 also includes agrotechnical and weather effects (in unknown ratios).

b) An "infinite" trend function is calculated (tending towards the initial stages of cultivation), in which case

$$q_0 \to q_{00}. \tag{20}$$

It is known, however, that the value of q_{00} cannot be obtained in practice, and that

$$q_{00} > q(F), \tag{21}$$

because q_{00} also includes weather effects, according to Eq. (5).

In practical calculations it is particularly obvious that q_0 and q_{00} cannot be realistic estimates for the effect of the soil factor: if the level of cultivation does not rise (or only rises negligibly slowly, which was fairly characteristic of earlier periods), then $\bar{q}(t)$ is constant and $q_0 = \bar{q}(t) = q(F)$ which is impossible; it may also occur in certain periods that $\bar{q}(t)$ shows a decreasing tendency, in which case q_0 is the highest value of $\bar{q}(t)$; this would mean that $q(F) > q$, which is absurd; in such yield data time series the effects of the basic factors (with the exception of $q(M)$) are inseparable.

c) A very long (but practically attainable) trend function is calculated and this is assumed to reach some quite low production level, where the ratio of the effects of the basic factors can be interpreted according to Eq. (6). At the initial phase of the trend function the effect of weather, $q(M)$, over the average of a few (e.g. five) years can be approximately separated and described from Eq. (6) as:

$$q(A_k, F) = q_k - q(\bar{M}). \tag{22}$$

According to our assumption

$$q(A_k) \ll q(F), \tag{23}$$

so it can be approximately accepted that

$$q(A_k, F) \simeq q(F)_{max}. \tag{24}$$

The probable or actual soil effect could be expressed from Eq. (5) by analysing the data of a wild crop,

$$q(F) = q_{00} - q(\bar{M}). \tag{25}$$

This is unfeasible in practice. The minimum effect of the soil cannot be expressed either. In the subsequent analyses the effect of the soil will be expressed wherever possible from Eq. (24).

5. In practice the yield components are separated by the following method. A certain closed period (5—10 years) is marked out in the uppermost part of the trend function and within this period the yield for each year is broken down into its components using the appropriate equations. The data are averaged, and the means obtained are substituted into the yield equation (Table 1). Depending on the equations chosen, various special forms of the yield Eq. (3) are obtained.

The simplest breakdown can be carried out using Eq. (7), where $q(M)$ can be substituted from Eq. (9) and $q(A, F)$ is obtained as the remainder. Eq. (7) has the great advantage that it can be applied to any phase of the trend function.

If a low cultivation level is assumed, Eq. (6) can also be solved, in a way analogous to Eq. (7),

$$q_k = q(\bar{M}) + q(A_k, F). \tag{26}$$

Table 1

Yield components in

Year	t	q	$\bar{q}$	q_{opt}	q_{min}	q(M)	H(M)
1968	19	33.9	39.5	45.9	30.3	3.6	12.0
1969	20	45.4	40.9	47.0	31.4	14.0	1.6
1970	21	32.7	42.3	48.1	32.5	0.2	15.4
1971	22	45.3	43.7	49.1	33.6	11.7	3.8
1972	23	47.1	45.1	50.2	34.7	12.4	3.1
1973	24	50.0	46.5	51.3	35.8	14.4	1.3
1974	25	52.6	47.9	52.4	36.9	15.7	−0.3
1975	26	53.2	49.3	53.4	38.0	15.2	0.2
Mean		45.0	44.4	49.7	34.2	10.9	4.7

Note: $q_{min} = q(A, F)$; $q'(M)_{max} = q(M)_{max}/q_{opt}$; $q(F)_{max} = 5.6$ (ma/ha), determined from a hundred-year county data series (ERDŐS, 1980).

The most generally applicable yield equation is

$$q = q(M) + q_7(A) + q(F)_{max}, \tag{27}$$

which is obtained by using Eqs (9), (18) and (24).

Assuming the continuous existence of the most favourable weather conditions (when $q(t_i) = q_{opt}(t_i)$ every year), the equation for the optimum yield is

$$q_{opt} = q(M)_{max} + q_7(A) + q(F)_{max}, \tag{28}$$

obtained by using Eqs (8), (18) and (24).

The effect of the factors are most often given as relative values. The relative form of each yield equation can be produced as an analogue of Eq. (4), e. g. from Eqs (27) and (28):

$$q' = 1 = q'(M) + q_7'(A) + q'(F)_{max} \tag{29}$$

$$q'_{opt} = 1 = q'(M)_{max} + q_7'(A) + q'(F)_{max}. \tag{30}$$

As an example let us write down the solutions of Eqs (27) and (28) (in the absolute and relative forms) on the basis of the data of Table 1:

using Eq. (27): $45.0 = 10.9 + 28.6 + 5.6$; $1 = 0.242 + 0.636 + 0.124$
using Eq. (28): $49.7 = 15.5 + 28.6 + 5.6$; $1 = 0.312 + 0.575 + 0.113$.

It can be seen that about one-quarter of the average yield is due to the effect of weather, nearly two-thirds can be attributed to the development of agrotechnics, while the direct effect of the soil is little more than 10%. In this yield structure the high cultivation level and a relatively high reliability of production are already reflected. The structure of the optimum yield is very similar, except that the absolute and relative effects of the weather are necessarily somewhat higher.

maize. Békés county

$q(M)_{max}$	$q'(M)$	$H'(M)$	$q'(M)_{max}$	$q'(A, F)$	$q'(A)$	$q'(F)_{max}$
15.6	0.106	0.354	0.340	0.894	0.729	0.165
15.6	0.308	0.035	0.332	0.692	0.568	0.123
15.6	0.006	0.471	0.324	0.994	0.823	0.171
15.5	0.258	0.084	0.316	0.742	0.618	0.124
15.5	0.262	0.066	0.309	0.737	0.618	0.119
15.7	0.288	0.026	0.306	0.716	0.604	0.112
15.4	0.298	0.000	0.294	0.702	0.595	0.106
15.4	0.286	0.004	0.288	0.714	0.609	0.105
15.5	0.227	0.135	0.314	0.774	0.646	0.128

From the data in Table 1 it is also easy to see that in some years the yield components may fluctuate a great deal, so reliable general conclusions can only be drawn on the basis of yield functions calculated from average values.

The results of more detailed yield structure analyses will be presented in subsequent papers.

*

Prepared at the Meteorological Department of the Eötvös Loránd University, Budapest.

L. Erdős

References

Csáki, Cs.—Varga, Gy.—Vendégh, F. (1972): A kukorica terméshozamát meghatározó néhány tényező vizsgálata a komáromi állami gazdaságban (Some factors determining the yield of maize in the Komárom State Farm). Gazdálkodás, **16/2** 45—54.

Dmitrenko, V. P. — Дмитренко В. П. (1973): Математическая модель урожайности сельскохозяйственных культур. Труды УНИГМИ, вып. **122,** 3—13. Гидрометиздат, Москва.

Erdős, L. (1976): A termés szétbontása a környezeti tényezők hatásainak arányai szerint (Breakdown of yield as a ratio of the effects of environmental factors). Földrajzi Értesítő, XXV, 61—79. Budapest.

Erdős, L. (1980): Changes in the yield structure of maize. Acta Agron. Hung., **29,** 50—62.

Ezekiel, M.—Fox, K. A. (1970): Korreláció és regresszió analízis (Correlation and regression analysis). Közgazdasági és Jogi Kiadó, Budapest.

Glenday, A. C. (1955): The mathematical separation of plant and weather effects in field growth studies. Austr. J. Agr. Research, **6,** 813—822.

Konstantinov, A. R. — Константинов А. Р. (1966): Схема учета влияния погодных факторов на прирост растительной массы и урожай. Труды УНИГМИ, вып. **58,** 3—30. Гидрометиздат, Ленинград.

Konstantinov, A. R. — Константинов А. Р. (1976): Климат и урожай пшеницы. 32. Гидрометиздат, Ленинград.

Mészáros, S.—Csepregi, I. (1972): A kukorica termésátlagát befolyásoló tényezők vizsgálata regressziószámítással (Regression analysis of factors determining yield averages in maize). Gazdálkodás, **16/11** 7—18.

Sabanov, V. V. — Сабанов В. В. (1973): Биоклиматическое обоснование мелиорации. 165, Гидрометиздат, Ленинград.

Theiss, E. (ed.) (1958): Korreláció és trendszámítás (Correlation and trend calculation). Közgazdasági és Jogi Kiadó, Budapest.

INVESTIGATIONS ON DEVELOPMENT OF METHODS OF BREEDING VALUE ESTIMATIONS FOR BEEF CATTLE

The results summarized in this paper will be presented at the 30th Annual Meeting of the Genetics Commission of the European Association for Animal Production to be held in Harrogate (United Kingdom) from 22—26th July 1979. The statements made are also likely to be of interest to cattle production specialists. The following is a short review of the investigations and conclusions.

A) *The applicability of the USA selection index in the Hungarian Fleckvieh breed.* The selection index adopted from the regional beef breeding research programme of the USA (DOHY 1977) is as follows:

$$\text{yearling weight} - 3.2 \times \text{birth weight}.$$

According to the American research report, by using this index the efficiency of integrated beef production can be increased by about 6—7%. Using this statement as a starting-point, the aim was to discover the extent to which the yearling body weight could be increased while restraining the birth weight, and consequently the calving difficulties. Examinations were made on the relationship between the selection index and

the birth weight,
the daily weight gain in the test period, and
the body weight at the age of 1 year.

Table 1

Results of the calculations

Index number	
mean	291
standard deviation	50.4
CV%	17.3
Birth weight	
mean, kg	39.4
standard deviation, kg	6.3
CV%	15.9
Daily weight gain	
mean, g	1076
standard deviation, g	104
CV%	9.6
Yearling body weight	
mean, kg	409
standard deviation, kg	80.9
CV%	19.8
Coefficients for correlation of index number with	
birth weight	r = 0.485
average daily weight gain	r = 0.752
yearling body weight	r = 0.805

Table 2

Index numbers as influenced by the birth weight and yearling body weight

Birth weight, kg \ Yearling body weight, kg	340	370	400	430	460	490	520	550
30	244	274	304	334	364	394	424	454
35	228	258	288	318	348	378	408	438
40	212	242	272	302	332	362	392	422
45	196	226	256	286	316	346	376	406
50	180	210	240	270	300	330	360	390

for producing bulls of high breeding value

for culling

for producing cows of high breeding value

Table 3

Coefficients of rank correlations within the performance test (PET) and the progeny test (PRT) results, and between performance and progeny test results

Rank correlations	Angus			Polled Hereford			All breeds+		
	r_{rank}	n ♂	n/progeny group	r_{rank}	n ♂	n/progeny group	r_{rank}	n ♂	n/progeny group
Within performance test									
Weight at 205 days — weight gain	−0.73*	9	—	0.90*	5	—	−0.32	19	—
Weight at 205 days — weight at 365 days	0.05	9	—	0.60	6	—	0.52**	26	—
Within progeny test									
Birth weight — weight at 205 days	0.08	9	160	0.14	6	60	0.36	27	108
Birth weight — weight gain	0.75*	9	160	⁎	—	—	0.25	17	139
Between performance test and progeny test									
Weight at 205 days	−0.22	9	203	1.00***	6	68	0.18	26	129
Daily weight gain	−0.13	9	32	⁎	—	—	0.12	15	27
PET weight at 205 days — PRT birth weight	0.63	9	160	0.14	6	60	0.56**	27	107
PET weight at 205 days — PRT weight gain	0.22	10	31	⁎	—	—	−0.12	18	24
PET weight at 365 days — PRT weight gain	0.60	9	32	⁎	—	—	−0.59*	17	25

+ All breeds: 10 Angus, 3 Red Angus, 3 Simmental, 3 Hereford, 6 Polled Hereford, 1 Shorthorn, 1 Gelbvieh, 1 Pinzgauer, 2 Chianina, altogether 30 sires.

* Level of probability 5%. ** Level of probability 1%. *** Level of probability 0.1%.

⁎ Owing to the small population no calculation could be made.

The calculations were made on research data for 111 Hungarian Fleckvieh young bulls fed individually from 90 days of age until the achievement of 550 kg slaughter weight (BÁRCZY *et al.* 1975). The results are summarised in Tables 1 and 2. From the data presented the following conclusions can be drawn:

— The index is twice as highly correlated with the yearling body weight than with the birth weight, i.e. this parameter increases the latter to a lesser extent.

— For a Fleckvieh population, as a "terminal sire line" for beef cattle production, the following may be suggested:

1. Progeny tested bulls with an index number above 390 can be taken into account as sires to be mated to elite cows for producing bulls of high breeding value.
2. Progeny tested bulls with an index number above 270 can be taken into account as sires to be mated to cows intended for the production of female replacers of high breeding value.
3. Sire candidates with an index number under 270 should be culled.

B) *Evaluation of performance and progeny testing results.* The beef sire population owned by the American Breeders' Service (ANONYMOUS 1977) deserves attention in respect of both semen import and results of general interest. Taking data from this bull population as a basis, evaluations have been made to explore the relationships

— among performance tests results,

— among progeny tests results, and

— between performance test and progeny test results, aimed at the modernisation of the selection system.

The results are given in Tables 3 and 4.

Table 4

Relationships between performance and progeny test results for all breeds

	Sires (Number of bulls)	r_{rank}	r
Weaning weight (at 205 days of age)	26	0.18	0.24
Weight gain	15	0.12	0.15

It may be stated that:

1. Within the performance test the rank correlations between the weaning weights at 205 days of age and the daily weight gains in the subsequent experimental period for various breeds were different, but negative for the whole population involving all breeds. The inconsistent results draw attention to the influence of pre-weaning antecedents on the post-weaning period of life, and furthermore to the fact that performance testing in beef breeds should be carried out when the bulls are as young as possible.
2. Within the progeny tests an increase in daily weight gain results in an increase in birth weight (and vice versa).
3. Correlations of the average weaning weight at 205 days between the progeny tests and the performance tests showed great differences for the various breeds; however, a slight positive correlation was found for the average of all breeds.
4. The statement reported in point 3 holds in respect of average daily weight gain as well.
5. The average birth weight in the progeny test was greatly increased by the weaning weight at 205 days in the performance test.

6. A surprising finding is the definite negative correlation between the yearling body weight in the performance test and the average daily weight gain in the progeny test. This may be attributed to both genetic regression and different environmental effects.

These results emphatically call attention to the fact that performance tests can only be regarded as a preselection method, and both performance and progeny tests should be carried out using methods specially standardised for the purpose and type of utilisation.

*

Prepared at the Agricultural College, Kaposvár.

I. Boda, J. Dohy, Á. Kovách

References

Anonymous (1977): American Breeders' Service Bull Appraisal Summary.
Bárczy, G.—Boda, I.—Molnár, I. (1975): Növendék bikák 90 napos korban kezdődő, különböző intenzitású hizlalása (Fattening of young bulls from 90th day of age at different levels of nutrition). Állattenyésztési Kutatóintézet Közleményei, **2/2**, 15—41.
Dohy, J. (1977): Utijelentés az Egyesült Államokban tett öthónapos tanulmányútról (Report on a five-month study-tour in the USA). MTA, MÉM, Mezőgazdasági Főiskola, Kaposvár, 1—71.

EFFECT OF ANTITRANSPIRANTS ON SOIL AND PLANT WATER STATUS IN GRAIN SORGHUM

Antitranspirants have received attention in recent years as a means of decreasing water loss from plant systems and the use of these chemicals has been regarded as an approach to the improvement of the water use efficiency by plants and the control of internal water deficits. Antitranspirants increase the internal water status of the plants (Miller 1969, Davenport *et al.* 1972, Patil—De 1976). Increased leaf water potential causes increased cell elongation and plant growth (Davenport—Hagan 1975). The favourable effect of antitranspirants on water use efficiency has been observed either due to reduced water use or increased yields (De 1974, Mizrahi *et al.* 1974, Ali—Prasad 1975). This study was undertaken to study the effect of antitranspirants on soil and plant water status in grain sorghum.

Field experiments were conducted at Tamil Nadu Agricultural University, Coimbatore, during the summer and monsoon seasons of 1977 under conditions of limited water supply to study the effect of antitranspirants on grain sorghum (CSH 5). The soil of the experimental fields was well-drained sandy clay loam with low available N (142 kg/ha), medium available P (14.7 kg/ha) and high available K (197 kg/ha). The rainfall received in the summer season was 253.3 mm in 10 rainy days and during the monsoon season it was 477.9 mm received in 25 rainy days. The average maximum and minimum temperatures were 34.51 °C and 22.49 °C during the summer and 31.93 °C and 22.46 °C during the monsoon season.

Three factors, namely moisture level, antitranspirant and time of application of antitranspirant, were studied in a split plot design with three replications. The treatment details are given in Table 1.

The antitranspirants were applied with a hand-operated knapsack sprayer fitted with a fan-type nozzle. The spray volume was 800 l/ha; this was determined by a calibration trial. A surfactant (Teepol B-300) was used at the rate of 0.2% with atrazine and kaolin. Utmost care was taken to see that the spray reached both the surfaces of the leaves. The control plots received a water spray with surfactant alone to eliminate the possible variation, if any, due

Table 1

Treatment details

(a) *Main plots*

(i) Moisture levels — 2

M_1 — 2 irrigations at vegetative (30—35 days) and flowering (65—70 days) stages in addition to sowing irrigation

M_2 — 4 irrigations at vegetative (30—35 days), boot leaf (55—60 days), flowering (65—70 days) and grain development (80—85 days) stages, in addition to sowing irrigation

(ii) Time of application of antitranspirants — 3

T_1 — Application at 45 days
T_2 — Application at 60 days
T_3 — Application at both 45 and 60 days

(b) *Sub-plots* (Antitranspirants) — 4

A_1 — Control (Water spray)
A_2 — Atrazine as Gessaprim[1] at 250 g c.p/ha
A_3 — Kaolin[2] 6% (W/V) suspension
A_4 — Power oil [3](E-9267) 1% (V/V) emulsion

Plot size:

Gross = 6.30 × 1.35 m; Net: 4.95 × 2.55 m
Spacing = 45 × 15 cm. Fertilization = 90, 45 and 45 kg N, P_2O_5 and K_2O/ha

	Summer	*Monsoon*
Date of sowing:	March 3rd 1977	July 25th 1977
Date of harvest:	June 15th 1977	November 5th 1977

Note: 1. Gessaprim, a commercial product, contains 50% a.i. of atrazine.
2. Kaolin was supplied as Nekolin lumps by the Nayveli Lignite Corporation, Neyveli.
3. Power oil was supplied by the Krishi Oil Corporation, Bangalore.

to water in the spray fluid. The soil moisture content was determined gravimetrically from samples taken at depths of 0 to 45 cm. The depth of water required at each irrigation was calculated using the formula suggested by DASTANE (1967):

$$\frac{\text{field capacity} - \text{actual moisture content}}{100} \times \text{bulk density} \times \text{depth of root zone}$$

This was multiplied by the area of the plot to arrive at the volume of water required for each plot. The water was measured by regulating the flow through a 90° triangular weir. The effective rainfall was estimated as suggested by DASTANE (1967). The relative water content of the leaves (RWC) was measured by the method suggested by WEATHERLEY (1950) and modified by BARRS—WEATHERLEY (1962).

The treatments failed to register a significant effect on the crop during the summer season owing to the continued and unusual rains received after flowering. Hence, the discussion is mainly oriented to the results obtained in the monsoon season. In summer, the rainfall received up to 45 days was meagre. Thereafter it was more or less uniformly distributed during the later stages of crop growth. Hence the available soil moisture was kept well above the critical level of 50% and no moisture stress developed. As a result the summer crop behaved just like a bulk crop and the treatments had no effect on the crop.

Table 2

Effect of antitranspirants on soil and plant water status

Treatments	Consumptive use of water (mm)	Grain yield, kg/ha		Water use efficiency	
	Monsoon	Summer	Monsoon	Summer	Monsoon
Moisture levels					
Low	311.4	5663	3816	35.74	40.72
High	389.5	5705	3847	36.59	32.78
S.E.	—	118	178	—	—
C.D.	N.S.	N.S.	N.S.	—	—
Times of application of antitranspirants					
1. At 45 days	346.3	5720	3921	36.12	37.08
2. At 60 fays	359.4	5772	3712	35.75	34.85
3. At both 45 and 60 days	345.7	5620	4010	36.63	37.00
S.D.	—	144	217	—	—
C.D.	—	N.S.	N.S.	—	—
Antitranspirants					
1. Control	358.4	5575	3502	35.43	33.67
2. Atrazine	344.9	5868	4164	37.37	38.02
3. Kaolin	348.3	5723	4128	35.73	37.38
4. Power oil	350.2	5620	3923	36.49	35.37
S.E.	—	125	274	—	—
C.D.	—	N.S.	561	—	—

1. *Consumptive use of water.* The total consumptive use was 400.9 mm in the summer season irrespective of the treatments. During the monsoon season (Table 2) the antitranspirant treatments, atrazine (344.9 mm), kaolin (348.3 mm) and power oil emulsion (350.2 mm), recorded less water use than the control (358.4 mm). Though the reduction in consumptive use due to antitranspirants was small, owing to the continued occurrence of rainfall during the later stages of vegetation, the reduced evapotranspiration (ET) might have resulted in higher soil moisture availability during the most critical stage of the crop (boot leaf stage). This consequently prevented the crop from developing drought symptoms at this stage. The application of antitranspirants at 45 days was more effective in reducing the consumptive use since the application was made at the critical time of water stress.

2. *Evapo-transpiration rate.* The effect of antitranspirants on ET at different times of application at different moisture levels is presented in Fig. 1. ET was higher during the pre-flowering stage than in the later stages due to the effect of climatic factors, such as high temperature, greater sunlight hours, and consequently higher PET during this period. Atrazine reduced the ET to a greater extent. Being a stomatal inhibitor, atrazine would have caused greater reduction in transpiration (Smith—Buchholtz 1962). Kaolin would have increased the albedo of the foliage and thus decreased the net radiation load on the canopy and leaf temperature. This probably reduced the transpiration (Gale—Hagan 1966, Davenport *et al.* 1969). However, when applied at 60 days, the antitranspirants did not have much effect because of the lower net radiation load due to continued rains and overcasting of the sky. This probably reduced the transpiration rate and so delayed stress development. Power oil also reduced the ET, but to a lesser extent, possibly due to a less than complete formation of a physical barrier.

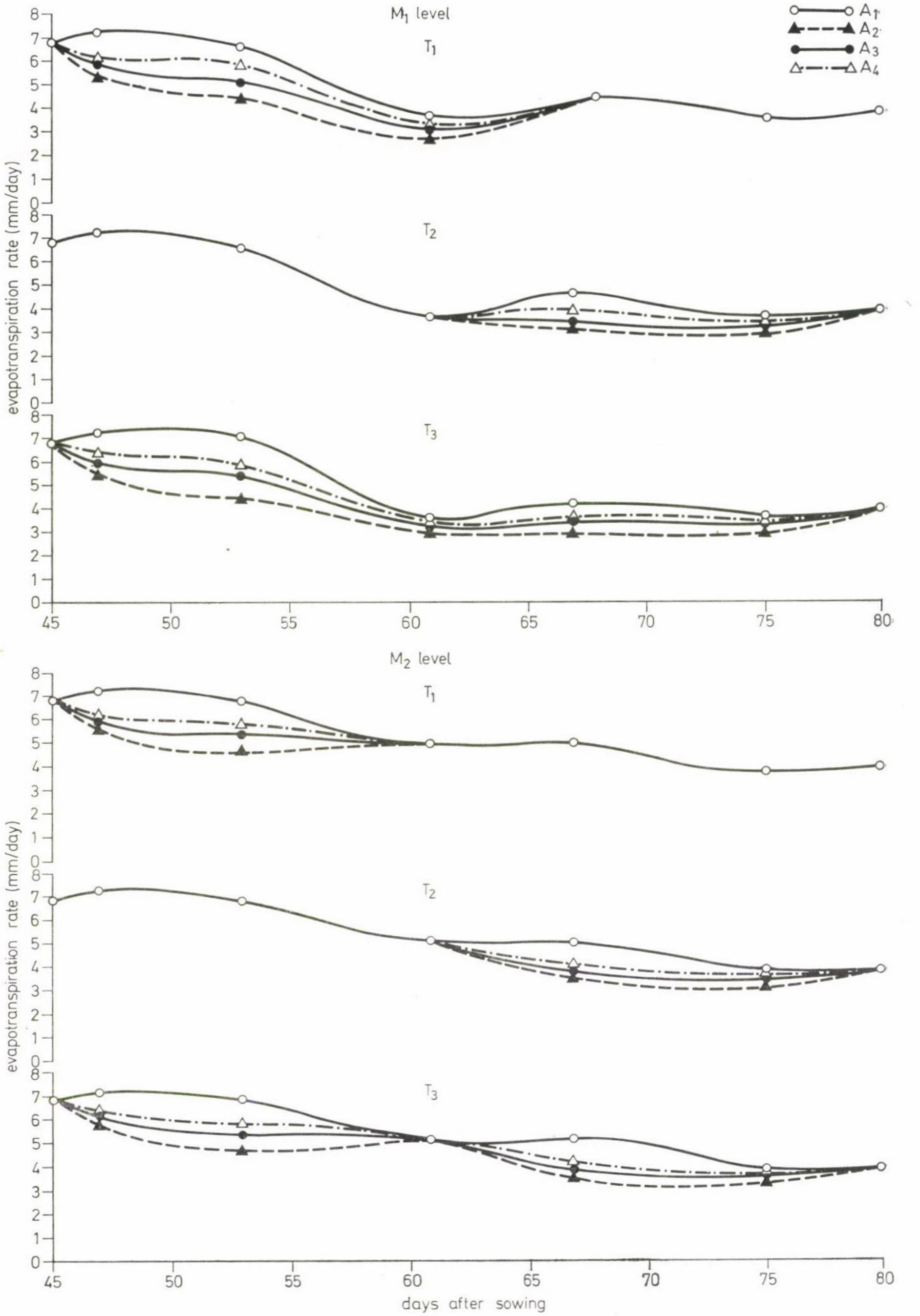


Fig. 1. **Evapo-transpiration rate — monsoon season**

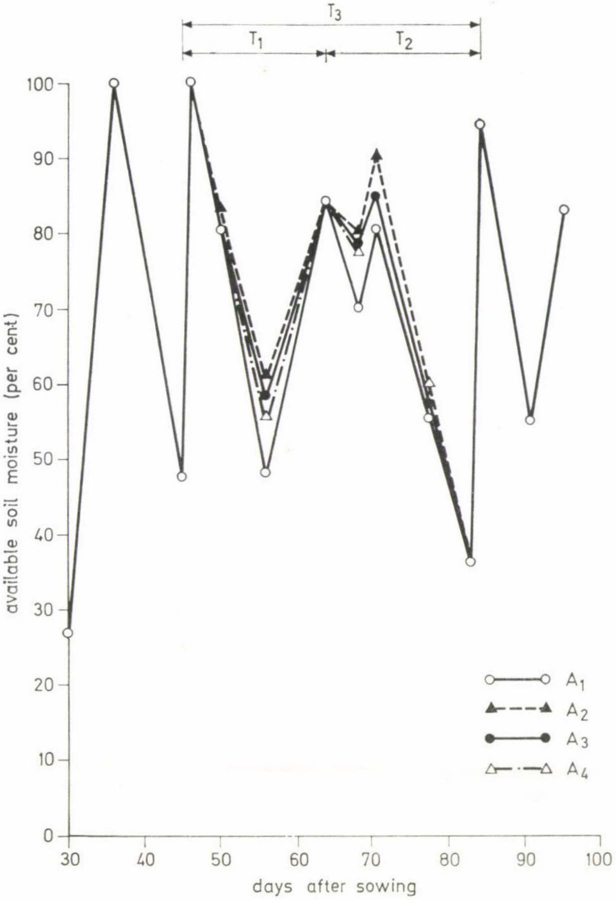


Fig. 2a

In general, it is evident that antitranspirants reduced ET more effectively at lower moisture levels when applied at 45 days. The reduction in ET was 12—30% for a period of 15—20 days after application.

3. *Available soil moisture (ASM)*. The ASM measured during the summer and monsoon seasons is presented in Figs. 2(a) and 2(b). The ASM was low at 30 days (27.5%) in summer and thereafter a somewhat higher percentage of ASM was maintained throughout the crop period. It never went below 50% after 30 days. Hybrid sorghum yields were maximum when the crop was irrigated at 50% depletion of ASM in the 0 to 30 cm soil layer (PALANIAPPAN *et al.* 1977). Hence the summer crop behaved like a normal irrigated crop. During the monsoon season, antitranspirants increased the ASM to a considerable extent, especially at the low moisture level. At the low moisture level, and when applied at 45 days, atrazine registered a higher ASM (21.5%) when compared to the control (5.2%) at the boot leaf stage. Kaolin and power oil recorded 16.5% and 15% ASM respectively. The application of antitranspirants reduced the transpiration with the ultimate effect of reducing the ET. The reduction in ET may have resulted in higher ASM during the period when the crop was subjected to stress. Increased

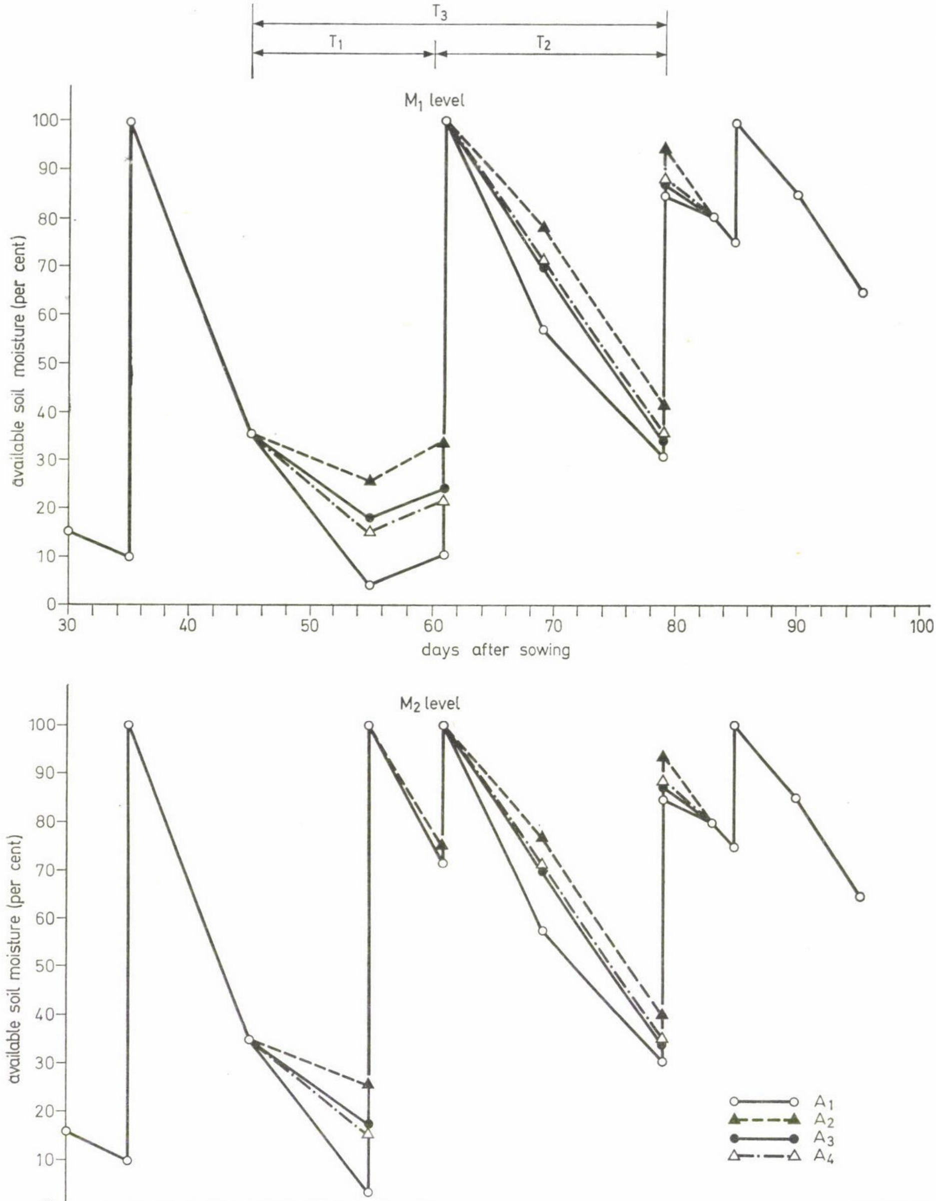


Fig. 2b

Fig. 2. a) **Available soil moisture — summer season; *b)* Available soil moisture (%) — monsoon season**

ASM at this stage caused an immediate recovery of photosynthesis, resulting in increased yields.

4. *Relative water content (RWC).* The effect of antitranspirants on RWC during the monsoon season is presented in Fig. 3. At the initial stages, the RWC of the crop was 94.2% but it start to decline as the stress developed. However, the decline stopped and the RWC

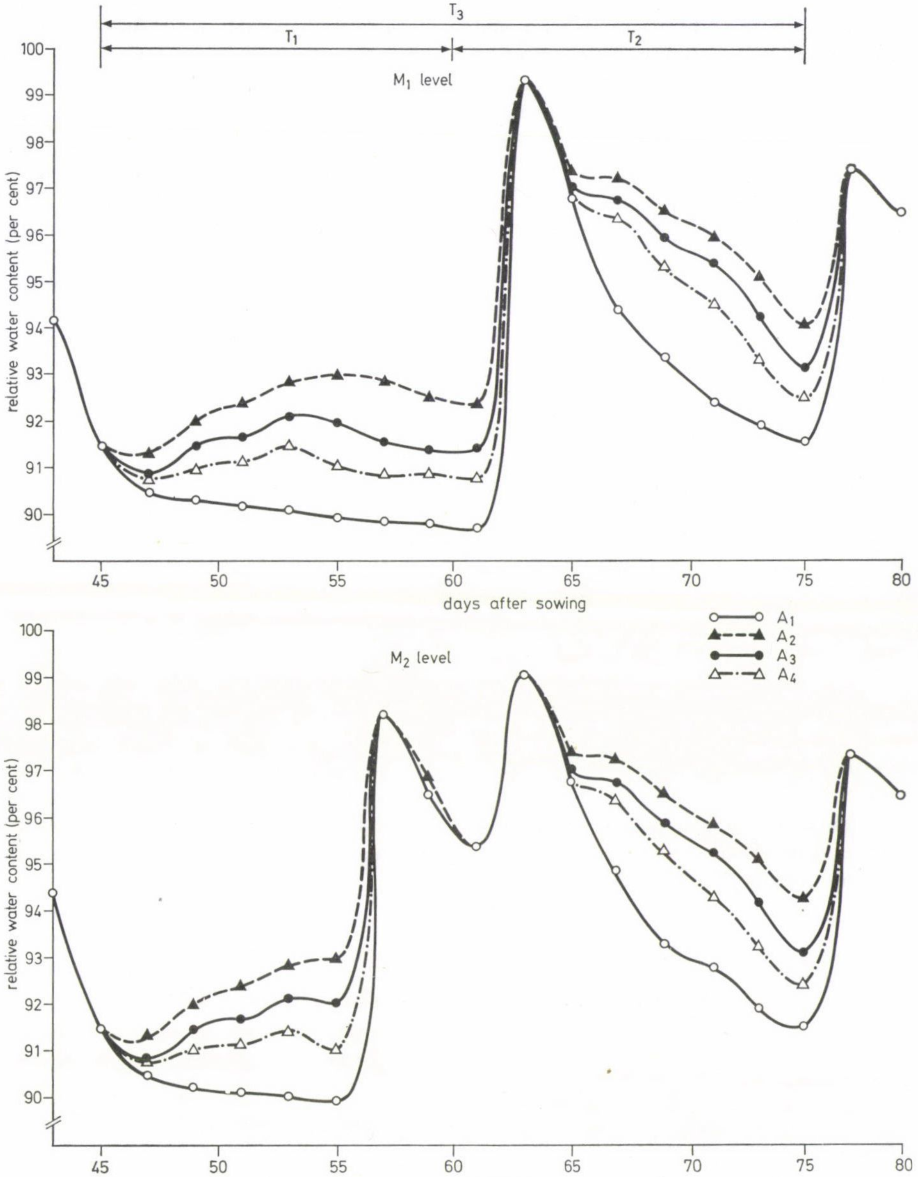


Fig. 3. Relative water content of leaves — monsoon season

levelled off as it reached a value of about 90%. The RWC again increased upon rewetting, either by irrigation at the high moisture level or by rains in the later stages at the low moisture level. The RWC showed a reduction as the ASM start to decline.

With the onset of drought conditions, a progressive and continuous decline in the RWC of the plant could be observed, due to continued transpiration or to the lag between absorption and transpiration (KRAMER 1969). This led to an internal water deficit, i.e. a loss in turgor of the plants in the control plots. As the decline in RWC continued, the drought resistance mechanism of sorghum may have come into operation, which, by closing the stomata at a fairly high RWC, reduced the rate of decline of RWC. The application of antitranspirants increased the RWC by 2 to 4% for about 10—15 days at both the moisture levels. Antitranspirants closed the stomata, decreased the radiation load or blocked the free movement of water, depending on the type of antitranspirant used, thereby reducing the transpiration. The reduction in transpiration may have resulted, on the one hand, in maintaining the RWC without further reduction, and on the other, in increasing the ASM due to the reduction in ET. Higher RWC has been found to be a good indicator of the ability of the crop to absorb and translocate nutrients and water (BASLER *et al.* 1961). Antitranspirants did not inhibit the root uptake of water (GREEN *et al.* 1970), so the increased ASM may also have contributed to the higher RWC. A combination of all these factors may have resulted in the increment of RWC when the crop was treated with antitranspirants. Sorghum normally maintains a fairly high RWC and hence the reduction in RWC during the early stage could be considered critical, as it went below 92% (PASTERNAK 1968). Increased RWC is an important factor because plant growth depends not only on the accumulation of raw materials via photosynthesis and mineral uptake but also on maintaining a high water potential to enable cell elongation (DAVENPORT—HAGAN 1975). The maintenance of higher RWC would produce a large amount of dry matter by controlling the internal water deficits (DOWNEY 1971) in one phase and achieving cell elongation in the other (BOYER 1968). In general, the overall effect of antitranspirants could be attributed to decreased ET (Fig. 1), increased ASM (Fig. 2a, b) and RWC (Fig. 3). All these favourable effects would have increased the availability of soil moisture, mitigated the adverse effect of water stress, controlled the internal water deficit and ultimately increased the dry matter production and yields.

5. *Water use efficiency (WUE)*. Antitranspirants increased the WUE to a considerable extent. Atrazine treated plots had the highest WUE (38.03) followed by kaolin (37.3) and power oil emulsion (35.37). The control plots recorded the lowest WUE (33.67). The favourable effect of the antitranspirants on WUE was due to both reduced water use and increased dry matter production. Antitranspirants were found to be more effective at the low moisture level than at the high moisture level. Application at 45 days generally increased the WUE since the application was carried out at the critical time of the vegetative phase when stress symptoms were beginning to develop.

Acknowledgement

The senior author wishes to gratefully acknowledge the financial help given by the Indian Council of Agricultural Research, New Delhi, in the form of a junior fellowship during the course of this study. He is also thankful to the Tamil Nadu Agricultural University for granting permission to publish his thesis.

*

Prepared at the Tamil Nadu Agricultural University, Coimbatore.

A. KUGANATHAN, SP. PALANIAPPAN

References

ALI, M.—PRASAD, R. (1975): Soil moisture studies in fallow barley rotation under mulches, antitranspirant and type of seed bed. J. Indian Soc. Soil Sci., **23**, 163—171.

BARRS, H. D.—WEATHERLEY, P. E. (1962): A re-examination of the relative turgidity technique for estimating water deficits in leaves. Australian J. Biol. Sci., **15**, 413—419.

BASLER, E.—TODD, G. W.—MEYER, R. E. (1961): Effect of moisture stress on absorption, translocation and distribution of 2,4-dichlorophenoxy acetic acid in bean plants. Plant Physiol., **36**, 573—576.

BOYER, J. S. (1968): Relationship of water potential to growth of leaves. Plant Physiol., **43**, 1056—1062.

DASTANE, N. G. (1967): A practical manual for water use research. Navabharat Prakashans, Poona.

DAVENPORT, D. C.—HAGAN, R. M. (1975): Role of antitranspirants in arid agriculture. In: Physiological aspects of dryland farming, U.S. Gupta (ed.) Oxford and IBH Publishing Co., New Delhi, 315—326.

DAVENPORT, D. C.—HAGAN, R. M.—MARTIN, P. E. (1969): Antitranspirant research and its possible application in hydrology. Water Resour. Res., **5**, 735—743.

DAVENPORT, D. C.—MARTIN, P. E.—HAGAN, R. M. (1972): Antitranspirants for conservation of leaf water potential of transplanted citrus trees. Hort. Sci., **7**, 511—512.

DE, R. (1974): Development of agronomic practices for unfavourable rainfed conditions. Information Bulletin, Cereal improvement and production, Near East Project, **11**, 9—14.

DOWNEY, L. A. (1971): Effect of gypsum and drought stress on maize (*Zea mays* L.) I. Growth, light absorption and yield. Agron. J., **63**, 569.

GALE, J.—HAGAN, R. M. (1966): Plant antitranspirants. Ann. Rev. Plant Physiol., **17**, 269.

GREEN, D. G.—FERGUSON, W. S.—WARDER, F. G. (1970): Effects of decenyl succinic acid on 32 P uptake and translocation by barley and winter wheat. Plant Physiol., **45**, 1—3.

KRAMER, P. S. (1969): Water stress and plant growth. In: Plant and soil water relationships. Mc Graw Hill, Inc., New York, 347—390.

MILLER, N. A. (1969): The effects of several transpiration retardants on the water balance, stomatal aperture and leaf temperature of field corn leaves. Diss. Abstr., **29**, 3640 B.

MIZRAHI, Z.—SCHERINGS, S. G.—MALIS ARAD, S.—RICHMOND, A. E. (1974): Aspects of effect of ABA on the water status of barley and wheat seedlings. Physiol. Plant., **81**, 44—50.

PALANIAPPAN, SP.—RAMASWAMY, R.—PANNERSELVAM, V.—BALASUBRAMANIAN, A. (1977): Studies on irrigation at critical stages of growth in *Sorghum*. Madras Agric. J., **64**, 281—284.

PASTERNAK, D. (1968): Studies on the use of antitranspirants on grain *Sorghum*. IV. 159 p. M. S. Thesis., Univ. Queensland, Australia.

PATIL, B. B.—DE, R. (1976): Influence of antitranspirants on rape seed (*Brassica campestris*) plants under water stressed and non-stressed conditions. Plant Physiol., **57**, 941—943.

SMITH, D.—BUCHHOLTZ, K. P. (1962): Transpiration rate reduction in plants with atrazine. Science, **136**, 263—264.

WEATHERLEY, P. E. (1950): Studies in the water relations of the cotton plant. I. The field measurement of water deficits in leaves. New Phytol., **49**, 81—97.

FORUM

OUR GUEST IS

DR. ANDRÁS SOMOS

VICE-PRESIDENT OF THE
HUNGARIAN ACADEMY OF SCIENCES

PÁL, GY.: Sir!

According to the estimates, in 30—50 years' time the population of the Earth will be 8 thousand million. If the per capita energy consumption increases by 3% a year (minimum growth), 30—50 years from now the energy requirement will be five times as much as it is at present. Yet the scarcity of energy carriers sets limits to the fulfilment of the energy demand. Do you think that out of season produce should be produced by the consumer country in greenhouses or under polythene at the cost of a considerable amount of energy, or should they be purchased instead from countries where they grow in the field at the given time, taking the costs of transportation into consideration too?

SOMOS, A.: **It is only possible to give a precise answer to the question if the actual conditions are known. In the case of Hungary: the demand for out of season produce can be satisfied primarily through production under polythene or in greenhouses and, to a certain extent, in the field. The solar and geothermic energy supply in Hungary makes it possible to grow early vegetables by utilizing these cheaper energy sources. Under Hungarian conditions a certain amount of produce may even be exported after satisfying the domestic demand; at the same time, temporary supplements from imports may also be necessary, mainly in winter.**

Countries must thus decide for themselves to what extent the demand for out of season vegetables can be economically met from domestic production and when imports are justified.

The decisive elements in the costs of supplying the home market are the expenses of building forcing facilities, the price of fuel and the cost of labour, which at present consists mostly of manual work. In the case of imported goods the costs of transporting and loading make up the bulk of the expenses.

*

PÁL, GY.: *In the opinion of the FAO (Food and Agriculture Organization of the United Nations) in capitalist countries with developed industries two main types of farm will take shape. One is the up-to-date large-scale agricultural production enterprise, where the production tools and the labour force are optimally exploited, while the other, the small farm, serves to supplement the incomes of non-agricultural workers. In your opinion in which type of farm will horticultural plants be primarily and decisively grown?*

SOMOS, A.: Horticultural plant species are grown in Hungary in both types of farm. Vegetables for processing are already grown under large-scale conditions. In this category the overwhelming majority of work processes can already be mechanized, thus substantially reducing the cost of manual labour.

For the production of out of season vegetables small-scale farm conditions will probably be preferable for some time, since machines which do not damage the quality of the crop are not available for the time being, and hand picking is necessary to ensure the required marketing quality of the produce.

*

PÁL, GY.: *The area of vegetable crops in Hungary decreased from 120 000 ha in 1970 to 112 000 ha by 1975 and was then expected to further decrease. An attempt was made to administratively counterbalance this reduction in the production area and the loss of yield involved by laying down for each farm the amount and kind of vegetables to be grown. Do you think it right to abolish the country's traditional vegetable growing districts by exercising pressure on farms to produce vegetables?*

SOMOS, A.: No, I do not think it right. Vegetable growing should continue to be concentrated in the traditional horticultural districts, because production is generally the most economical in places where the local natural conditions (climate, soil, water supply) best suit the biological demands of the vegetables grown.

*

PÁL, GY.: *In Hungary traders have to pay 70% of the consumer prices for out of season produce to the producers. Traders are only obliged to accept the agreed amount of produce from large farms, but from small producers any amount of marketable goods must be accepted, because in the case of small-scale producers greater care must be taken to ensure risk-free production. When exporting vegetables and fruit, on the other hand, the slow rate at which the producers change over to new varieties represents a permanent problem. In your opinion, does risk-free production slow down or accelerate the changeover to new varieties, or does it not affect it at all?*

SOMOS, A.: In judging the effects of a change in variety a distinction must be made according to whether we are considering fruit, vine or vegetable growing. In fruit and vine growing it undoubtedly slows down the process and lessens the producers' willingness to make a change of variety, since it takes several years for new varieties to start bearing.

The situation is different in the case of vegetables, where a change in variety can be carried out within a year. This is why the changeover to new varieties is considerably faster in vegetable production than in fruit and vine growing. No time is lost due to the changeover, perhaps occasioning re-plantation. No replanting and regrafting costs arise either. From the producer's point of view the endeavour to changed varieties has a favourable effect on the reliability of production. The higher yielding ability and better quality of the new varieties lead to better marketability and higher income.

*

PÁL, GY.: *The number of days spent by visitors in hotels and rooms for paying guests in Somogy, Veszprém and Zala, the three counties surrounding Lake Balaton, was 700,000 in July 1965, and more than 2 million in July 1975. In these three counties the total horticultural area was 8.9, 6.4 and 3.4 thousand ha respectively in 1965, and 8.4, 6.4 and 4.2 thousand ha in 1975, while the orchard area was 6.4, 5.5 and 13.9 thousand ha in 1965 and 6.8, 5.7 and 13.0 thousand ha in 1975. During these ten years tourism grew threefold while the area of gardens and orchards was reduced or at best did not change. In your opinion which are likely to become the vegetable and fruit growing regions supplying Lake Balaton ?*

SOMOS, A.: In supplying the area around Lake Balaton with horticultural produce the southern shore will continue to play a decisive role, due to its more favourable natural conditions, which have led to horticultural production developing there on a larger scale. The biggest centre of horticultural production is the Siófok district. Owing to its location Balatonaliga may also play an important part in supplying the southern and northern shores in the years to come. The Keszthely district is in a similar position; horticultural produce can again be delivered from there to both sides of Lake Balaton over relatively short transportation distances. The role of Balatonfüred on the northern shore is similar to that played by Siófok on the southern side. As for vine growing, Badacsony and its environs cannot be left out of consideration.

*

PÁL, GY.: *The production costs of apple growing in 1975 amounted to 17.70 Ft for the equivalent of 1 rouble, and 13.43 Ft in the dollar area. The exchange earnings index expressing the forint value of domestic investment per unit currency in the same year was 39.82 in the rouble area and 43.79 in the dollar area in the case of fresh vegetables and fruit. In your opinion, with the present demand for horticultural produce and the favourable exchange earnings index, is the fact that Hungarian apples can only be sold well in the case of a poor apple yield in the Western-European countries due to favouritism, discrimination or the low quality of the produce ?*

SOMOS, A.: The competitiveness of apple growing in Hungary is influenced by each of the factors listed (favouritism, discrimination and poorer quality). This applies particularly to winter apples. Summer varieties are not available in sufficient quantities; there are years when even the local demand cannot be fully satisfied.

*

PÁL, GY.: *In Hungary it frequently happens in industry that an industrial plant or enterprise commissions a research institute to solve a problem it is interested in, and the research institute then delivers the results of its research to the consigner. Some think that this method is much more expensive than buying a licence or know-how, while according to others it is* *cheaper because it does not involve the payment of currency. What is the reason, in your opinion, for the fact that a similar system of commissioned research has not developed in agriculture ?*

SOMOS, A.: The main reason is that agricultural research works with living materials (plant varieties and animal breeds), and the differences in ecological conditions do not allow the adopting of research results without local comparative trials. The local adaptation of procedures purchased in the form of licences or know-how often takes up as much time as would be required for solving the problem on the spot. This is particularly true in the case of introducing new varieties.

*

PÁL, Gy.: *It was earlier held that every nation lived from its past, from the works of the great men of the country, and that any nation which forgot its departed leaders was itself on the way to oblivion. Today the explosion of information caused by the mass of new scientific results is slowly becoming an obstacle to progress. In the present information explosion, when it is difficult to keep pace with the recent results in even a small field of science, how is it possible, in your opinion, to take the scientific achievements and prominent personalities of the past into consideration as well ?*

SOMOS, A.: Well-grounded scientific research cannot be carried out without a knowledge of the historical traditions. So it is necessary to "fight on two fronts" even during the "information explosion", which in our case means that an objective evaluation of the traditions of the past offers the surest basis for solving new research tasks successfully. Without knowing the achievements of the past, research may easily come to an impasse, which can, however, be avoided by a thorough study of the precedents.

*

PÁL, GY.: *The mean producer's price on the market for kohlrabi was 3.10, 4.60, 6.10, 9.10 and 8.30 Ft/kg in 1965, 1970, 1975, 1976 and 1977, respectively, while that for potato was 3.10, 3.35, 4.50, 6.70 and 6.20 Ft/kg in the same years. The steadily rising tendency of the mean producer's market prices has led to the producers becoming quantitatively orientated. The per ha yield of kohlrabis weighing 1 kg each is very high and the quality too is excellent, but what is the housewife supposed to do with such a large kohlrabi ?*

SOMOS, A.: Kohlrabis weighing 1 kg are fairly rare in practice. Most of the varieties grown do not reach that size. Really large types are generally found among varieties grown for winter consumption. These varieties can be stored for months without any difficulty, and the housewife can use the necessary amount any time by cutting up a large kohlrabi. Even retailers often sell it in pieces, together with parsnip, carrot and celeriac, for making soup.

PÁL, GY.: *At present, according to the botanical records, there are 600,000 plant species on the Earth, 250,000 of which are flowering plants, while the others are known as lower plants. A full mapping of the flora of the Earth is now being carried out; during the last twenty-five years 6,000 new plant species have been discovered in Africa alone, and even in Central Europe there are recently described plant species. Most of the still unknown plant species are almost certainly to be found in the tropics. Do you, as an expert in vegetable cultivation, think it likely that any plant not used at present for human consumption might in the future be utilized as a source of food or raw material in Hungary ?*

Somos, A.: Yes, I do. It can be stated without any particular deliberation that the present range of vegetables could be widened by new vegetable species which are hardly if ever consumed in Hungary so far. These include, for example, the eggplant, Chinese cabbage, chicory, mangold, and various edible mushrooms, such as *Pleurotus ostreatus (florida)*, *Stropharia rugoso-annulata*, *Coprinus comatus*, etc.

•

Pál, Gy.: *Thank you for the information.*

CHRONICA

50TH ANNIVERSARY OF THE GARST AND THOMAS HYBRID CORN COMPANY

In spring 1979, Roswell Garst (1898–1977), founder of the Garst and Thomas Hybrid Corn Company, which celebrates its 50th birthday this year, was voted into the Businessman's Hall of Fame by the editors of Fortune Magazine. No worthier person could have been chosen than the humanitarian Roswell Garst, pioneer and innovator of agriculture, to occupy the 46th place in a line which includes such notabilities as George Washington, Benjamin Franklin, Thomas Edison, Henry Ford, Walt Disney and others.

"... history will someday record that Roswell Garst influenced agricultural people as much as anybody", writes agricultural historian Hiram Drache in his book "Beyond the Furrow".

In many countries of Central and Eastern Europe, including Hungary, the name Garst is synonymous with the development of food production.

Searching back through 25 years of Garst memories and a fairly extensive archive collection, I came across the February 1976 copy of the Farm Journal, which was devoted to the American Bicentennial and which contained some characteristic statements by Bob* Garst. These were made to editor Lane Palmer in a telephone conversation he had with Bob during the compilation of the celebration issue. Palmer quotes Garst as follows:

"Certainly the American farmer is a hybrid. The crossing of all those different nationalities has made North American farmers — Canadian as well as U.S. — more progressive. I think our people are an excellent example of hybridization.

"I guess you could consider me a hybrid. My mother migrated from England as a girl. The people on my father's side came from Alsace-Lorraine. The original spelling of our name was Gerst.

"I would not credit all of our agricultural achievements to the hybridization of our people any more than I would credit our 300-bushel yields just to the use of corn hybrids. Many other factors entered in, such as the richness of our soil and our rainfall pattern. But hybrids make the most of it."

1. How it all began

My own initiation into American agriculture began on Apple Farm in Coon Rapids. This was the Iowa settlement where Bob's father, Edward Garst, settled in 1869, just after graduating from the University of Michigan, and 12 years before the railway reached Coon Rapids in its progress towards the West. Edward was a good trader and in time he became rich and bought a great deal of land at cheap prices. At first the Garst family rented Apple Farm, which got its name because Bob's uncle, Warren, who was governor of Iowa for several years at the beginning of the century, planted an apple orchard around the farmhouse.

It was on this 200-acre farm that Bob and his brother Jonathan settled and started farming in 1915. As Jonathan writes, at that time Thomas Jefferson would have felt very much at home on Apple Farm: although the land was naturally richer than the rolling hills of Virginia, they grew the same crops apart from tobacco, namely maize, oats, clover and a little wheat. The maize was still picked by hand and it sometimes took from October till the middle of winter before all the maize got from the fields to the barns, and although farm implements had developed during the 90 years since Jefferson's death, they were still drawn by horses. The Garst brothers had 8 draught horses and raised a foal or two. They kept 20—

* Roswell Garst was usually known by his nickname Bob.

30 cows and fattened a wagonload or so of steers. Apart from this, they had about a dozen sows and fattened the litters.

But Bob and Jonathan soon went their separate ways. Jonathan was a soldier in World War I, then farmed in Canada, while Bob became a university student from autumn 1919. For three years he studied everything from smithing to philosophy at Iowa State College, Wisconsin University and Northwestern University, which is why he used to say "I am not highly educated but broadly educated". Bob Garst returned to Apple Farm in 1922 to continue farming and married Elizabeth Henak, to whom he attributes much of his success.

For four of the remaining 55 years of Bob Garst's life he and Elizabeth did not live on Apple Farm: in 1926, to see how town life suited them, they rented out the farm and moved to the Iowa state capital Des Moines, 120 km from Coon Rapids, where Bob worked in the real estate business. Here they were destined to meet the Wallaces. Henry Wallace, who was later to become Franklin Roosevelt's Secretary of Agriculture and then his vice-president, had been experimenting with the hybridisation of maize inbred lines since 1913, and also edited a farm magazine which was founded by his grandfather in the eighties and continued by his father. Henry Wallace and Bob Garst both had an unflagging interest in farming, so they soon became close friends, and this brought a turning point in the Garst's lives.

In 1926 Henry Wallace set up the Hi-Bred Corn Company (now the Pioneer Hi-Bred Corn Company), and in 1927 Bob Garst bought his first bushel of hybrid maize seed. In 1928 and 1929 he doubled the quantity each year, because the hybrid gave much higher yields than the open pollinated maize previously grown on Apple Farm.

Meanwhile, in autumn 1929, the economic crisis erupted. All the signs indicated that the crisis would be long and severe, as did an editorial in Henry Wallace's journal in early 1930, so Bob and Elizabeth Garst decided that if the depression was likely to last for years they would be better off as peasants on the farm than with no income in the town. But before they moved back to Apple Farm in spring 1930, Bob Garst suggested to Henry Wallace that if the Hi-Bred Corn Company provided him with foundation stock he would produce hybrid maize seed and would pay royalties for producing and selling it. Apart from a reasonable profit this would also cover research costs. They agreed to the conditions of their cooperation but never signed a written contract: not only during Bob Garst's lifetime but right up to the present day, the Garsts have received their foundation stock and settled with the seed company founded by Henry Wallace on the basis of this verbal agreement.

2. Missionary for hybrid maize

Bob and Elizabeth Garst returned to Coon Rapids and produced their first hybrid maize seed in 1930. The sowing area for the hybridisation was only 10 acres, giving a yield of 300 bushels of hybrid seed, which was one tenth of the total hybrid maize seed produced in the USA that year. But even so, it was no easy matter to sell the seed, as the farmers, who had been hit by the depression, knew nothing about the advantages of hybrid maize. So it is no wonder that Bob was obliged to spend the winter of 1930—31 driving from farm to farm with a carload of hybrid seed, trying to sell his 300 bushels to the farmers a bushel or two at a time. It was a job which required the zeal of a missionary. The genius of Bob Garst lay in grasping the fact that the marketing of a completely new product would be most successful on a farmer-to-farmer basis, rather than through peddlars "with a little knowledge of many things, but no real understanding of anything".

That same winter of 1930—31, Bob and Elizabeth Garst asked Charlie and Bertha Thomas, who were also born in Coon Rapids and were farming there, to join them in producing hybrid maize seed in cooperation with the Hi-Bred Corn Company. This was the beginning, just 50 years ago, of the Garst and Thomas Hybrid Corn Company. From then on Charlie Thomas was responsible for producing the hybrid seed, and Bob Garst for selling it.

Bob came up with an almost inexhaustible stream of ideas for popularising the stiffly priced hybrid maize seed. For years after the founding of the Garst and Thomas Hybrid Corn Company about a tenth of the hybrid seed produced was packed each year into 8-pound bags. These bags were then distributed free to the best of the farmers who had refused up to then to "waste" their money on hybrid seed. In return, all they asked these farmers to do was to put their own seed into one box of the 2-row seeders then in use, and the hybrid seed in the other. This meant that every second pair of rows in the maize field consisted of high-yielding hybrid plants carefully selected for standability, from which it was not only easy to pick the ears, but which also gave a perceptibly higher yield than the farmer's own maize.

Fig. 1. Elizabeth and Bob Garst at the entrance to the **Garst** Farm

Bob usually sold his seed for cash, but he was not inflexible in this respect either. In his first year as US secretary of agriculture, Henry Wallace let Bob Garst have 1000 bushels of 2-year-old hybrid maize seed. Garst distributed the seed among the enterprising farmers, with the stipulation that they should pay him half the market price of the surplus yield compared to their own varieties. In the majority of cases Bob's share of the deal was so much that he confesses to having had rather a guilty conscience at pocketing the proceeds.

Throughout the thirties Bob Garst spent the best part of his time driving over farm tracks, only some of which were properly surfaced, to reach the farmers and try to ensure that all the maize fields were planted with hybrid seed. His argument was as simple as the factually-based calculation involved. Using the standard cultural practices of the thirties the farmer could achieve a yield surplus of at least 10 bushels/acre if he were prepared to pay the money equivalent of 2 bushels of his own maize extra for the hybrid maize required to sow each acre of land.

But all the efforts of this brilliant salesman would almost certainly have been in vain, were it not for the fact that the Garst and Thomas Hybrid Corn Company aimed at perfection right from the start in producing seed and processing it for planting. Garst never claimed his product was perfect, but the company did everything in its power to achieve perfection. This endeavour is well illustrated by their twice rebuilding the hybrid maize seed plant during the economically anything but easy thirties. The first seed processing plant, built in 1930, was rebuilt in 1934. Then, after another four years, in 1938, they inaugurated a new plant, which was the biggest and most modern in the world, three times the size of the next biggest seed plant in America.

Prior to 1937 the Garst and Thomas Hybrid Corn Company only marketed hybrid maize seed in South West Iowa, but from 1937 onwards they extended operations to the states of Nebraska, Missouri, Kansas, Oklahoma and Colorado, where the farmers were almost totally unfamiliar with hybrid seed. So here in the South Western Corn Belt, Garst played a pioneer role in popularising hybrid maize seed.

This process, which started slowly at the beginning of the thirties, gathered momentum towards the end of the decade. In 1930 only a fraction, 0.02%, of the maize seed sown in the USA was of hybrid origin, and this ratio was still only 10% in 1936, but from then on only a brief decade was required for it to reach 80% by the mid-forties.

The spread of hybrid maize and of mechanical pickers had a mutually stimulating effect. The pickers could only work efficiently in strong-stalked, standing maize fields; the use of the picker, on the other hand, raised the maize-producing potential of the farms, as they were no longer restricted by the 100 bushels/day capacity of the manual pickers. Thus it is hardly surprising that the fifteen years from 1930 to 1945 saw the triumph in the USA not only of hybrid maize seed but also of the mechanical picker, both of which gained ground from virtual non-existence to almost universal application.

3. Hybrid maize + N-fertiliser ≅ high yield

As in the case of hybrid maize, the Garst company endeavoured to demonstrate the usefulness of other developed cultural practices too. Every step on the road to development, as Bob Garst claims, made the farmers more susceptible to new ideas. From the end of the second world war, Bob, the missionary of hybrid seed, became the apostle of chemicals, principally of nitrogen fertiliser. He was supported in this by a team of hundreds of salesmen recruited from among the best farmers. From the second half of the thirties, at the instigation of Bob's scientist brother, Jonathan Garst, who worked for a number of years at the US Department of Agriculture, fertiliser treatments were included in the excellent demonstrations of hybrid maize set up on various farms. The conclusion to be drawn from this became more and more obvious to Bob Garst, his enthusiastic farmer salesmen and, through them, to the farmers of the South-Western Corn Belt and beyond: there is no use in developing high-yielding plants if the nutrients required for the expression of the yield potential are not provided, nor is there any use in providing crops with abundant nutrients if the plant lacks the genetic potential to utilise the nutrients. The emergence of fertilisation as the most efficient yield-increasing technique in American farming circles, was facilitated by the fact that from the end of the forties the American explosives factories went over to fertiliser production, so there was no shortage of cheap nitrogen fertiliser.

As intensive fertilisation gained ground, more and more farmers planted maize in their best fields year after year without rotation. This in turn necessitated effective soil insecticides, while efficient herbicides were required to overcome the weed growth stimulated by fertilisation.

The cooperation, based on free enterprise, between the farmer and various specialists, professions and industries, turned American agriculture into a horn of plenty. With a certain

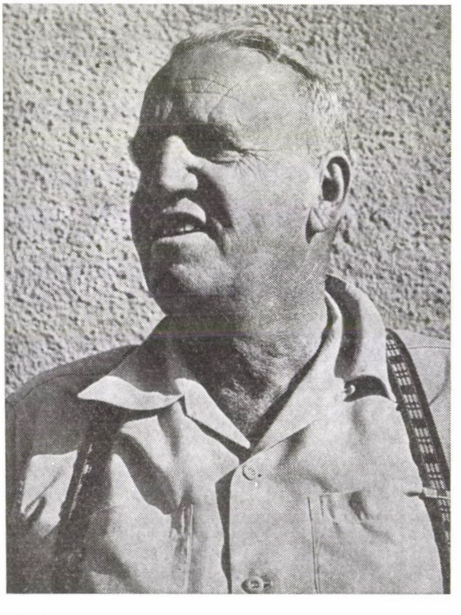


Fig. 2. Bob Garst — pioneer and innovator of agriculture

Table 1

Five-year averages of maize yield and nitrogen fertiliser applied in the USA
(compiled by Roswell Garst using USDA data)

Year	Sowing area of maize harvested as grain in 1000 acres	N active agent applied in 1000 tons	Average yield/acre in bushels	Total grain yield in 1000 bushels
1930–34	103 404	281.6	21.9	2 023 906
1935–39	92 899	371.2	25.0	2 050 232
1940–44	90 083	466.5	31.9	2 604 631
1945–49	85 696	778.3	35.6	2 771 638
1950–54	78 586	1 429.8	38.5	2 787 849
1955–59	66 409	2 197.0	48.7	3 234 891
1960–64	59 876	4 031.7	62.5	3 722 910
1965–69	56 728	5 948.3	78.5	4 453 489
1970–74	61 215	8 205.5	84.0	5 135 361
1975–79	70 088	10 054.4	94.9	6 657 795

It is noteworthy that while the sowing area has decreased by a good 30% the total yield has increased three and a half times.

degree of simplification, the specialists, professions and industries serving the farmer can be classed in three categories: the geneticist, who breeds new plants and animals, the chemist, who produces new chemicals, and the engineer, who rationalises and mechanises farm work. American agriculture, the result of this cooperation, is described by Fortune Magazine, in an article celebrating the election of Bob Garst to the Businessman's Hall of Fame in 1979, as the greatest triumph of American technology, an achievement even greater than putting a man on the Moon. This triumph is well illustrated by the 5-year averages for maize yields and the amount of fertiliser utilised in the USA during the five decades since 1930 (Table 1). With the exception of the figures for the last 5 years, the table was compiled by Bob Garst using data from USDA, and in one of his last letters to me on February 10th 1977, he made the following comments:

"It is my best judgement that the bulk of the increase in the yield of corn between 1930 and 1954 was due to hybridization of corn — and of using only the best land for corn as the acreage went down due to better yields. And some improvements in machinery.

"But the great increase since 1955 has been due to fertiliser, insecticides and herbicides — which lets farmers concentrate the corn on their best acres — and irrigation where water is available — and better drainage where drainage is needed."

4. Carbamide as a protein feed for ruminants

During the last third of his life Bob Garst was mainly occupied in developing maize waste (cobs and stalks) enriched with carbamide, mineral salts and vitamins, as a fodder for ruminants, and in popularising this technique.

In the thirties the utilisation of the maize cobs which were the waste product of the first hybrid maize seed processing plant, which took up the two central blocks of Coon Rapids, beside the railway track, presented no problem to the Garst company. Every family used coal for heating and cooking, and as coal cannot be ignited with a match, kindling was needed, e.g. dry maize cobs. However . . . by 1946 every household had an oil-stove or oil-fired boiler and cooked over natural gas, and they used no coal whatsoever.

"So we were desperate !" as Bob used to say when he told this story. They could not set fire to the enormous mountain of cobs towering above the processing plant for fear of causing everyone in the town to die of suffocation. At this point, in summer 1946, a gentleman turned up at Garst's office and offered to buy the mountain of cobs. When asked what he wanted them for, the gentleman replied that he intended to transport the cobs to California and sell them ground as cattle feed.

Up till then Bob had been taught that maize cobs had no feeding value, so he asked the man whether the law in California permitted maize cobs to be sold as cattle feed. The reply was that the Californian Secretary for Agriculture accepted the Ohio State University bulletin, which attributed feeding value to cobs when fed to cattle.

Bob Garst, who had not previously heard of the publication, wrote to Ohio State University, and received Paul Gerlaugh's bulletin in reply. In this he read that when fed up to one third of the feed, and when properly complemented with ground maize and protein, cobs were two thirds as valuable as shelled maize.

In a letter to Gerlaugh Bob explained that he had many tons of cobs at his disposal and that if he wanted to use them as one third of the cattle feed he would have to buy twice the amount of grain maize. So if properly complemented cobs had two thirds the value of shelled maize when fed up to one third of the feed, he asked Gerlaugh what value they had as three thirds of the feed. The reply was very brief: "I don't know!"

Then the Garst Company approached Iowa State University and offered to sponsor research aimed at answering the question, but the people there said they already knew that cobs had no feed value. So the Garsts went home and started experimenting themselves.

A bulletin published by Wisconsin University, in which Gus Bohstedt, who was in Jonathan Garst's year at university, reported on his research on carbamide as a cattle feed to replace plant protein, proved very useful in the experiments started on the Garst Farm in 1946 on the use of cobs as cattle feed. According to this bulletin, carbamide could be used "without any danger" as up to one third of the protein feed for cattle. Consequently, in the first cob-feeding experiments on the Garst Farm carbamide made up one third of the protein feed, while two thirds of the protein was supplied as soya meal. After a few years of experimentation, however, Bob realised that if carbamide was mixed with rapidly acting carbohydrate, e.g. molasses, it was capable of satisfying the full protein needs of the cattle, and if fed in combination with ground maize cobs, enriched with a minimal amount of alfalfa hay or artificial vitamin A and the necessary mineral salts, it could be used for feeding beef cattle.

Encouraged by the results, a highly successful demonstration was organised on the Garst Farm in August 1948 and this was used as an argument to persuade fodder specialists from Iowa State University to review and repeat the experiments. Iowa State University employed Wise Burroughs of Ohio State University to conduct the control experiments. In Bob Garst's opinion, Burroughs is one of the best cattle feed experts in the world. The control experiments carried out at the university in the winter of 1948—49 confirmed the conclusions drawn by Garst and company, which had been much debated in scientific circles.

After 20 years of experimentation Bob established the fact that maize waste (stalks and cobs) contained one third of the feed value of the maize yield, i.e. of the whole plant, and that, properly complemented with a little grain maize, and with carbamide, mineral salts and vitamin A, it was an excellent, cheap cattle feed.

Nowadays, as a protein substitute, carbamide and other non-protein nitrogen sources make up more than 10% of the total protein fed to livestock in the USA. Carbamide probably represents over half of all the protein supplements fed to cattle.

As a prophet of new ideas and techniques aimed at increasing farm efficiency, Bob Garst devoted his whole life to the suppression of famine and poverty. He was a pioneer in popularising the most highly developed American agricultural technology even beyond the borders of the USA, in Central and South America and in Central and Eastern Europe. When Nikita Khrushchov travelled to the USA, he insisted on visiting the Garst farm.

5. Garst's ideas in Hungary

I became acquainted with Bob Garst on his first trip to Central and Eastern Europe in early autumn 1955. He visited Hungary at the invitation of the Minister of Agriculture, Ferenc Erdei, and spent a whole day at the Martonvásár institute and farm.

At the time of Bob's visit to Martonvásár I had just been appointed director of the institute. It was a period of flux, searching for a profile. The social storms resulted in continual change, which is not always a useful component of scientific life. The changes claimed victims, and until the mid-fifties the profile and even the name of the institute was sacrificed several times within the first five years of its existence: the institute resembled nothing so much as an Eastern bazaar, dealing in virtually everything. In order to increase the research efficiency through specialisation and a concentration of forces, and to find a solution which would stand the test of time, my patron, Ferenc Erdei, tried to persuade me to work on maize research, but I had other ideas: theoretical genetics and wheat breeding were the height of my dreams. I tried to explain that in the person of the world-ranking breeder, Endre Pap, Martonvásár maize research was in the best possible hands, but that as director I would do everything in my power to see that Endre Pap's excellent hybrid maize received the greatest possible publicity.

So the visit to Martonvásár of Bob Garst, the prophet of hybrid maize, could not have come at a better time, nor could my pilgrimage (in the true sense of the word) not long afterwards to Iowa, the Mecca of hybrid maize. This took place in December 1955 and January 1956, when Bob Garst invited a 3-man Hungarian agricultural delegation to make a return visit. It is no exaggeration to say that the discussions held under Bob Garst's leadership on the Garst Farm and on at least a dozen other Iowa farms, at the seed processing plant of the Garst and Thomas Hybrid Corn Company, with Jim Wallace at the Pioneer Hi-Bred Corn Company headquarters, with Bill Brown at the Pioneer research laboratories and with Professor Sprague at Iowa State University, together with the debates in the family circle, stretching into the night, on what we had seen and heard, had a decisive influence on my career.

This combination of research and breeding with seed propagation, processing and marketing, a solution perfect in its way for shortening the time required for achieving scientific discoveries and putting them into practice, and which had proved so very efficient at the Garst and Thomas Hybrid Corn Company and the Pioneer Hi-Bred Corn Company, seemed an ideal solution for adaptation at Martonvásár. As a result of the seed supply system elaborated on the basis of the American experiences for application in Hungary, hybrid maize spread more rapidly in Hungary than in any other country of the globe.

The success of hybrid maize in Hungary, as in America, made Hungarian farmers more open to new scientific advances such as the utilisation of modern fertilisation, plant protection and other cultural practices. And this was not restricted to maize, but spread to Hungarian agriculture's other main crop, wheat, as well. Following the American example, the tripling of the Hungarian maize and wheat yield averages over the past quarter of a century was based chiefly on high yielding varieties and the nutrients necessary to ensure the full expression of this yield potential.

We were less fortunate, however, with the introduction into Hungary of maize waste complemented with a urea-molasses mixture as ruminant feed than we were with that of hybrid maize and up-to-date fertilisation. Nevertheless, after a good two decades, the fodder shortage caused by the drought in summer 1976 and a rational endeavour to farm economi-

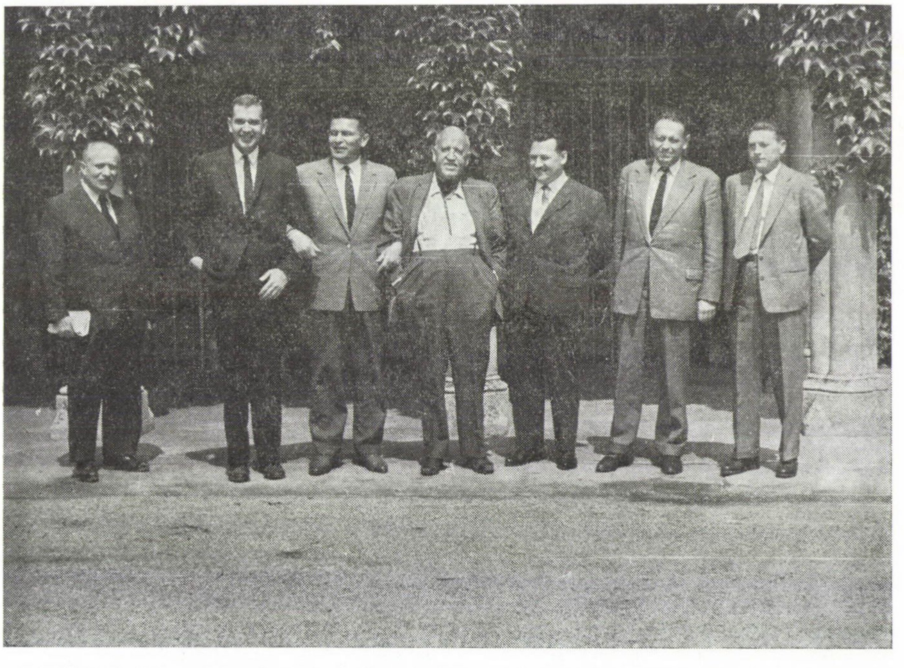


Fig. 3. With his Hungarian friends in front of the main building of the Martonvásár institute

cally, seems to have finally aroused real interest in this technique. Our visit to the Garst Farm in September 1976 with specialists from the institute's experimental farm and from the neighbouring state farm has been followed by a whole series of Hungarian farmer delegations.

Searching for the reason for this sudden rush of delegations and for the delayed awakening of interest, Bob wrote in his letter of February 10th 1977, already quoted above:

"Finally I mentally decided that you, Sándor Rajki, were the cause of interest in the use of molasses and urea as the protein for ruminants and I reasoned why it had taken so long.

"You are not a student of animal nutrition. Your education and your interest has not been even in plant nutrition — it has been in plant genetics.

"But . . . you have visited the United States frequently . . . and over the years you have seen our cattle operation grow and grow."

The motivation he gives for the rush of delegations may be mistaken, while his explanation of the delayed interest is probably correct, but what is incomparably more important is the fact that the technique is finally being put into practice in Hungary.

The first demonstration of the feeding experiment, in which maize waste (stubble grazing and stalk silage) enriched with carbamide, mineral salts and vitamins is fed to ruminants, was organised at the experimental farm of the Martonvásár institute in mid-October 1977. Bob and Elizabeth Garst were invited to attend and both of them wrote that they were looking forward greatly to their forthcoming visit to Martonvásár, but Bob's illness forced them to give up the idea. Barely two weeks after the demonstration we received the news that Roswell Garst had died on November 5th 1977.

*

Leo Schneider, whom I have known and respected since the beginning of my quarter-century acquaintance with the Garsts, wrote this of his late employer to the grieving family:

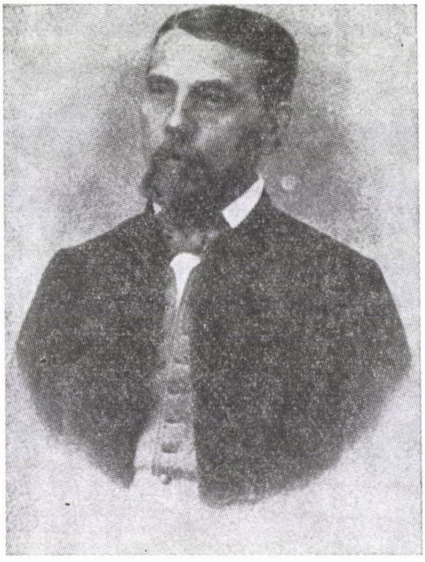
"Among the legacy Bob leaves us is . . . a constant urging to recognize truth, to learn how to do things better . . . to make progress. Among Bob's priceless attributes were his great wisdom, his boundless enthusiasm and a unique artistry of painting a picture in such a way that countless others understood and were inspired and enthusiastic in the pursuit of worthy endeavors.

"Even though I am retired I still feel his prodding to go forward. I am sure this feeling is present with you and is his challenge for all of us. If we heed it, we will all be better people, and this is what he would want. If he could speak to us now, I'm sure he would say . . . no grief for me; there is a job to do; get on with it."

And life goes on. The business management had already passed into younger hands years before Garst's death. His sons, Stephen and David, and his nephew, John Crystal, are partners in the Garst and Thomas Hybrid Corn Company, as are the three Thomas daughters, while my friend Dave Garst has long been one of the heads of the organisation.

This is how I see the brief story of the 50-year-old Garst and Thomas Hybrid Corn Company and of my talented friend Bob Garst, a story which American agriculture and the American people have every right to be proud of. I sincerely hope that this story will continue in the future for many years to come and through countless generations.

S. Rajki



JÓZSEF DORNER
(1808–1873)

This article commemorates József Dorner, one of the most prominent botanists of the 19th century, the 170th anniversary of whose birth was celebrated in 1978.

József Dorner was born on November 2nd 1808 in Győr. He attended secondary school first in his native town, then in Sopron. He started his career as a pharmacist as an apprentice in the apothecary's shop "The Hungarian King" in Sopron. He studied at Vienna university, and obtained a diploma in pharmacology in 1832. He was the owner of a chemist's shop in Pozsony for 4 years.

Right from his early youth botany was his favourite field of interest. Even as a secondary school student he studied the rich flora of the forests near Sopron with great interest. Later he travelled all over those parts of Hungary which abounded in the species he was interested in. He also spent a lot of time abroad. His first book, written on a study tour in the Bánát at the age of 31, and entitled "Das Bánát in topographisch-naturhistorischer Beziehung . . ." was published in 1839 and was such a success that it aroused the interest of contemporary scientists. He became friendly with the famous botanists of those times: Antal Rochel (1770—1847), warden of the botanical gardens in Pest, János Heuffel (1800—1857), physician-botanist, István Endlicher (1804—1849) the botanist known for his plant taxonomy, and József Sadler (1792—1849), professor of botany at Pest university and one of the leading personalities of the Royal Hungarian Society of Natural Sciences. He kept up a correspondence with foreign scientists, including the botanists Eduard Fenzl (1808—1879) in Vienna and H. G. Ludwig Reichenbach (1793—1879) in Leipzig.

In 1840 he sold his chemist's shop and took a post in the health department of the Governor's Council in Pest.

In 1846 he decided to compile and publish a manual on the flora of Hungary. Heuffel and Sadler welcomed Dorner's plan and offered to collaborate with him, but due to Sadler's death in 1849 and Heuffel's illness the plan was never realized; Dorner could not undertake the enormous work alone.

On March 13th 1847 József Dorner was elected as member of the Royal Hungarian Society of Natural Sciences. As one of the notabilities of the botanical committee he was invited to take over the book collection and other collections of the Society. He organized the enlargement of the collections through exchange.

During the war of independence he was invited to join the Ministry of Religion and Education of the first Hungarian government. However, after the capitulation it was impossible for him to return there, so he retired and devoted all his time to botany.

In 1853 he delivered a lecture at the Royal Hungarian Society of Natural Sciences with the title "The plant kingdom and man". In a paper published in the journal "Új Magyar Múzeum" (New Hungarian Museum) he discussed the Darwinist theory of evolution: "The times when botany was confined to the identification, of genera and species . . . have passed. The new science has assumed a higher standing. It no longer satisfies itself with the classification of forms . . ., but searches for their inner relationships . . . An attempt is made to become acquainted with the wonderful, simple organization of the plants, by which they build up their slender bodies, in order to obtain a deeper insight into the core and inner relationship of the highly diversified forms . . ."

In his paper "The plant cell" he anticipated, ahead of his time, the concept of bioenergy. He wrote: "The study of cells is the most remarkable part of the science of botany, which with the introduction of the microscope has become a most interesting subject . . . There exists in the cell a remarkable moving force, so far physically unidentified, whereby the cell content spreads in different ways unnoticed in the body of the plant . . ."

Thus, József Dorner realized that the tissue structure of plants would only become known through the regular use of the microscope. He also turned his attention to the life phenomena of plants, which is based on motion and metabolism. As early as 1853 he agreed with Engels in proclaiming: "Life is the mode of existence of the proteins, the essence of which is a continuous exchange of matter with the external environment surrounding them." This new, materialist approach to botany won him great respect. On December 15th 1858 he was elected as corresponding member of the Hungarian Academy of Sciences. The title of his inaugural lecture was: "Outline of the history and application of the microscope."

In the 1850s he taught natural sciences in the Lutheran Evangelist grammar school at Szarvas, then from 1860 in a similar school in Pest.

In 1863 at the IXth Congress of Hungarian Physicians and Natural Scientists, held in Pest, Dorner delivered a lecture on the "*Cuscuta* varieties of the Hungarian meadow". He pointed out that owing to their parasitic nature the dodder species differ from dicotyledons in their tissue structure. He presented details of the germination and development of the dodder, and mentioned the prevention of dodder infestation too. During the lecture he showed mature specimens of *Cuscuta*. This lecture was a great success and aroused the interest of a number of foreign botanists as well.

Dorner taught the Hungarian botanical terminology to Paul Ascherson (1843—1913), a botanist from Berlin, who then translated "*Cuscuta* varieties of the Hungarian meadow" into German.

In his paper "Budapest tölgyei" (Oak-trees of Budapest), published in the same year, he gave a summary of the Quercus species occurring in the environs of Budapest on the basis of his own observations.

In one of his last works he compared the flora of Pest county to that of Lower Austria. This study was completed with a detailed list of plants.

His secondary school text-books on botany, zoology and mineralogy were published in the 1860s. His scientific literary works include 8 books and many papers. In addition, a number of book-reviews and analyses were published in the "Magyar Tanügy" and in the educational column of the "Pester Lloyd".

His scientific prestige is illustrated by the fact that he was also a member of the Vienna Imperial and Royal Society of Botany and Zoology. He was very well educated in the humanities and languages. Thus, he also taught German literature in the upper classes of the Szarvas grammar school. He was an excellent teacher. He wished to pass on the very best of his knowledge and education. In the last years of his life he continued teaching in spite of his impaired health, until illness finally defeated him. He died in Budapest on October 2nd 1873. In worthy memory of his name, his legacy, an enormous herbarium, is kept in the Botanical Collection of the Museum of Natural Sciences.

József Dorner, botanist and teacher, was one of the most prominent pioneers engaged in studies on plant organization and physiology in Hungary.

According to Károly Kalchbrenner, the great botanist commemorated here "appeared at a time when the sience of botany was respected by very few in Hungary".

L. HEGEDÜS, L. SZMODITS

LECTIONES

EXPERIMENTAL RESULTS BY THE CROSS BREEDING OF MAIZE. MACROMUTANTS OF THE "CORN GRASS" TYPE*

One of the most important requirements for the development of animal husbandry production is the supply of fodder in the required quality and quantity. Maize plays a decisive role in the development of fodder production. It is principally used as corn-fodder, but it has been used for silo purposes in ever growing quantities during the last few years. However, only an insignificant number of maize hybrids are especially suitable for silo purposes. Thus, in the field of maize crossbreeding many trials have been made on the utilization of mutants in economical production.

BÁLINT *et al.* (1964) examined two inbred lines with various mutagen treatments. The examinations showed that when the irradiation dosage was increased, the number of chromosome aberrations also increased, but this result was not observed with EMS treatment. One inbred line was more susceptible to irradiation than the other, but the situation was reversed with EMS treatment.

BÁLINT *et al.* (1966) indicated that the variability of quantitative characters can be increased with acute gamma irradiation using doses of 5,000 and 15,000 rad. With 5,000 rad the proportion of plus variants increased more than with the 15,000 rad dose.

CHKHIKVADZE (1974) found good values for earliness, ear size and shape, and grain consistency in the M_4 generation of the mutant plants, when maize lines were treated with chemical mutagens.

ANDRIANOVA (1975) reported that high combining ability was shown by mutant lines when a study on yield, cold resistance, lodging, diseases and pests was made.

MORGUN—LARCHENKO (1975), studying the frequency and spectrum of the mutations induced by chemical mutagens, found that the substances DNEU and NDMU had higher mutagenic activity than NEU and NMU in several cases.

POTEKNINA (1975) studied variations in the "corn grass" mutant type for the yield component of 20 midseason radiomutants. The highest yielding lines were used in breeding programmes. The most promising were lines which combined high ear weight with high 1000-grain weight.

TKACHENKO—BARANOVA (1975) obtained some promising single crosses from crosses between different mutant lines obtained by treatment with gamma rays and DAB. Other single crosses from mutant lines were obtained by combining beta rays with DES.

CONGER (1976) found that the mutagenic efficiency increased as the dose of gamma radiation increased, but decreased with increasing doses of fission neutrons.

GAVRILYUK (1976) observed branching forms of plants derived from a "corn grass" mutant type obtained from the inbred line VIR-44 by gamma irradiation on pollen grains with a dose of 1500 rad. An analysis showed that the material, which consists of families

* Paper presented at the 9th ESNA meeting held in Brno, Czechoslovakia on September 4—9th 1978.

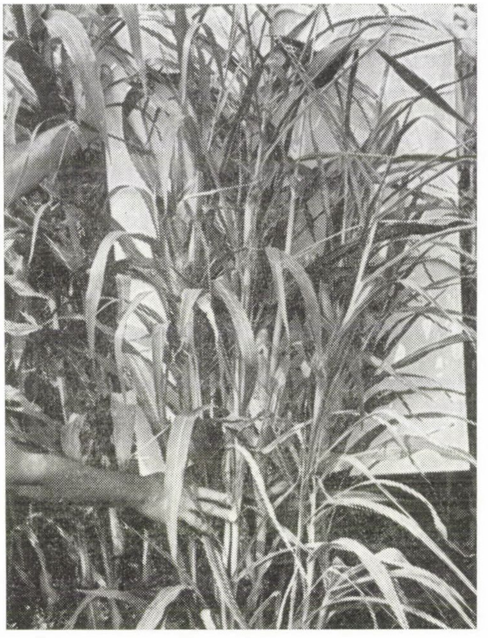


Fig. 1. "Corn grass" macromutant type

differing in morphological characters, includes different genotypes. Some variations were found in the progeny, both from inbreeding and from open pollination, when the following characters were studied: number of lateral branches per stem, number of tassel branches, tassel height, leaf length, leaf breadth, number of nodes per stem and plant height.

MORGUN—CHUCHMII (1976) found that fast neutrons induced the highest percentage of useful mutations and X-rays the lowest, when dry seeds of inbred lines were treated with X-rays, gamma rays and fast neutrons alone, or in combination with chemical mutagens, but the low doses gave the best results in the combined treatment. The best results were obtained with a 5,000 rad neutron dose and a 0.001% concentration of N-nitroso-N-ethylurea.

ISHALINA (1977a) found that short-strawed mutant plants differed from the initial forms in leaf colour, earliness and tillering capacity when pollen grains were treated with gamma radiation.

ISHALINA (1977b) observed several useful characters in new sublines in the fifth generation of maize radiomutants, which differed morphologically from the original forms and which were obtained by gamma-irradiating lines using various doses.

The present investigation was the first utilization of macromutant plants of the "corn grass" type (Fig. 1), obtained by gamma irradiation on pollen grains from maize inbred lines at the Institute of Plant Production and Ecology attached to the Debrecen Agricultural University.

The present investigation was carried out at the experimental plantation of the Agricultural University, Debrecen.

In the 1958 season the pollen grains of corn inbred lines were treated with a dose of 1.5 krad using a Co-60 gamma source, at the Medical University, Debrecen, and the plants were fertilized with the treated pollen. In the following year three different individual mutant plants were found in the M_1 generation, and these produced very rich mutant populations in the following generations. From plants with narrow leaves which grew into bushes the so-called "corn grass" macromutant type (Fig. 1) was selected and selfed in the following years, and this was later used for the present investigation, though it was not completely homozygous.

In the 1976 season, some crosses were made between macromutant plants of the "corn grass" type and an American inbred line B_{14}. The reciprocal cross was carried out as well.

In the 1977 season, seeds of the two parents, the F_1 hybrid and the reciprocal cross were planted in trial plots with 70×35 cm spacing. During the vegetation period and after

Table 1

The mean values ($\bar{x}$) of quantitative characters for parents, hybrid (SC.) and reciprocal cross

Characters	B_{14} inbred	Hybrid	Reciprocal	Corn grass	L.S.R. 5% / 1%		
Plant height (cm)	197.30	282.20	188.00	183.05	12.27 16.30	12.92 16.98	13.31 17.47
Shrub yield (g)	189.45	552.45	244.45	218.40	69.05 91.74	72.21 95.65	74.91 98.33
Number of ears	1.05	5.75	16.60	25.65	5.18 6.88	5.45 7.17	5.62 7.38
Number of tillers	1.00	4.30	7.45	8.45	1.61 2.14	1.69 2.23	1.74 2.29
Leaf length	82.05	89.20	65.95	62.70	4.47 5.94	4.71 6.19	4.85 6.37
Leaf width	9.83	9.30	5.18	3.93	0.82 1.09	0.87 1.14	0.89 1.17
Stem diameter	2.21	2.32	1.61	1.30	0.45 0.60	0.48 0.63	0.49 0.65
Number of leaves under the ear	7.85	8.65	6.20	7.45	0.97 1.29	1.03 1.35	1.06 1.39
Number of leaves above the ear	7.55	8.50	6.35	8.65	1.06 1.41	1.12 1.47	1.15 1.52
Number of tassel branches	14.00	25.55	28.90	7.15	8.07 10.72	8.49 11.17	8.75 11.49
Number of rows	14.70	12.90	10.20	8.50	0.85 1.13	0.89 1.18	0.92 1.21
Number of seeds per row	24.95	34.10	17.65	15.20	2.82 3.75	2.97 3.90	3.06 4.01
Ear length	15.38	15.47	9.56	8.35	0.88 1.17	0.93 1.22	0.95 1.25
Ear diameter	4.21	3.81	2.44	2.11	0.27 0.35	0.28 0.37	0.29 0.38
Cob diameter	2.49	2.53	1.57	1.45	0.14 0.18	0.15 0.19	0.15 0.20
100-grain weight (g)	21.86	20.67	12.83	15.16	3.46 4.60	3.65 4.79	3.76 4.93

Table 2

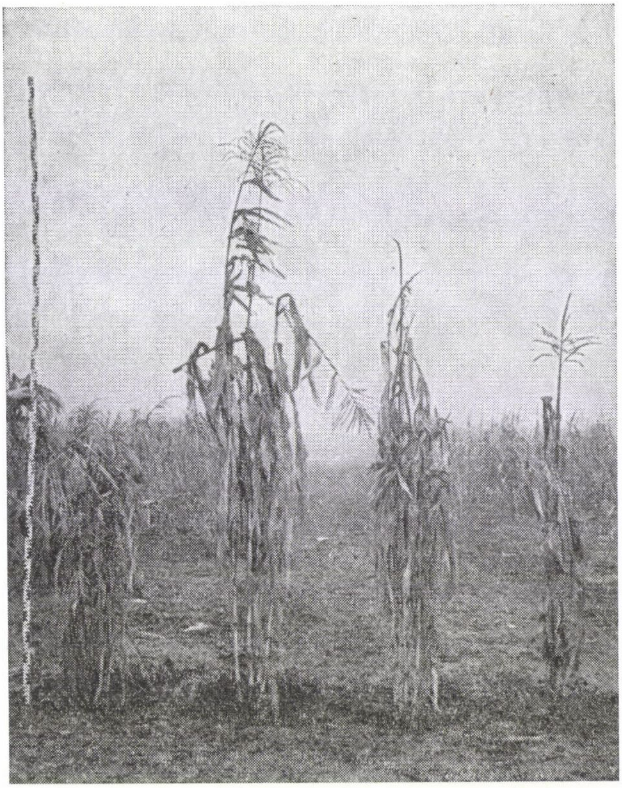
The mean values ($\bar{x}$) of yield for the parents together, compared to the hybrid and the reciprocal cross

Character	Parents together	Hybrid	Reciprocal cross	L.S.R. 5% / 1%		
Yield per shrub	407.85	552.45	244.45	82.78 109.98	87.17 114.66	89.80 117.88

harvesting, some agronomic characters were studied on 20 individual plants chosen at random from each plot, and the following characters were recorded:

1. Plant height was recorded before harvest; the measurements were carried out from the ground surface to the end of the tassel. 2. Yield per shrub (g). 3. Number of ears. 4. Number of tillers. 5. Leaf length. 6. Leaf width. 7. Main stem diameter. 8. Number of leaves under the ear. 9. Number of leaves above the ear. 10. Number of tassel branches. 11. Number of

Fig. 2. The hybrid (SC) ($B_{14} \times$ Corn grass)



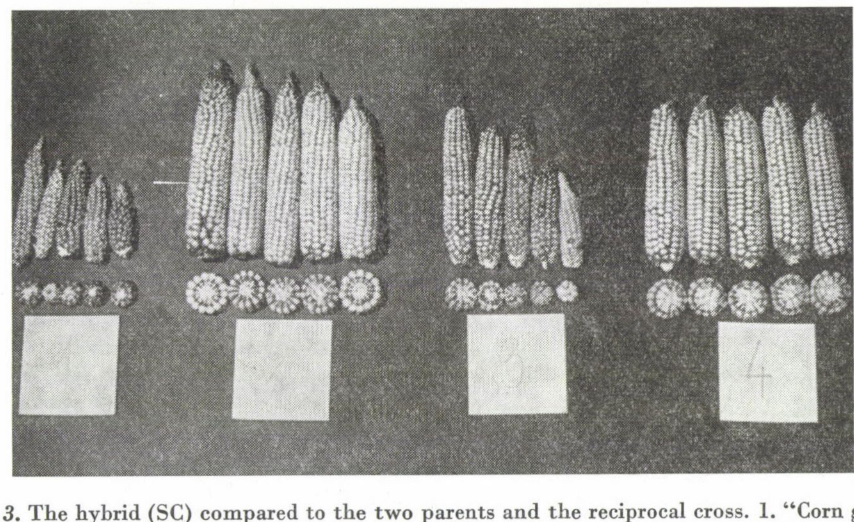


Fig. 3. The hybrid (SC) compared to the two parents and the reciprocal cross. 1. "Corn grass" macromutant type; 2. Hybrid (SC); 3. Reciprocal cross; 4. Inbred line B_{14}

rows. 12. Number of grains per row. 13. Ear length. 14. Ear diameter. 15. Cob diameter. 16. 100-grain weight (g). 17. Analysis of amino acids.

The results were statistically analysed, since every plant represented one replicate. Duncan's new multiple range method (L.S.R.) (KASIM 1975) was used, and a comparison between all the combinations was made.

In the hybrid, the B_{14} inbred was used as the mother, and the "corn grass" macro-mutant type was used as the father. In the reciprocal cross it was the opposite.

In the 1978 season a comparative trial was planted. The hybrid was compared to two Hungarian standard varieties, the silo-corn standard Mv Fv 26, and the grain-yield standard Mv 580.

The quantitative and morphological characters, yield, yield components and analysis of amino acids for the parents, hybrid and reciprocal cross (Fig. 3) are outlined in the following:

1. *Plant height.* The analysis of variance showed a highly significant difference between the hybrid and the two parents. The mean values of plant height are presented in Table 1. On average the hybrid was about one metre higher than the highest parent.
2. *Shrub yield.* Super heterosis appeared in this characteristic. Table 2 shows a highly significant difference between the yield of the hybrid and the parents's yield together.
3. *Number of tillers,*
4. *Leaf length,*
5. *Number of seeds per row,* and
6. *Cob diameter.* The analysis of variance for the above characters showed highly

Table 3

The analysis of amino acids for parents, hybrid and reciprocal cross

Amino acids	B_{14} inbred	Hybrid	Reciprocal cross	Corn grass
Lysine	2.98	2.54	2.43	2.05
Histidine	2.27	2.21	2.11	1.88
Arginine	4.30	3.67	3.79	4.02
Aspartic acid	7.55	7.54	7.26	7.12
Threonine	3.76	3.69	3.90	4.31
Serine	5.05	3.32	5.61	5.87
Glutamic acid	20.34	22.72	21.56	20.23
Proline	10.23	8.89	11.19	12.86
Glycine	4.09	3.39	3.40	3.42
Alanine	9.16	8.36	8.64	8.60
Valine	3.74	3.53	3.36	3.82
Methionine	2.17	2.15	2.16	2.04
Isoleucine	2.89	3.13	2.92	2.77
Leucine	12.89	14.79	13.04	12.81
Tyrosine	3.52	3.44	3.33	3.54
Phenylalanine	5.06	4.72	5.37	4.72

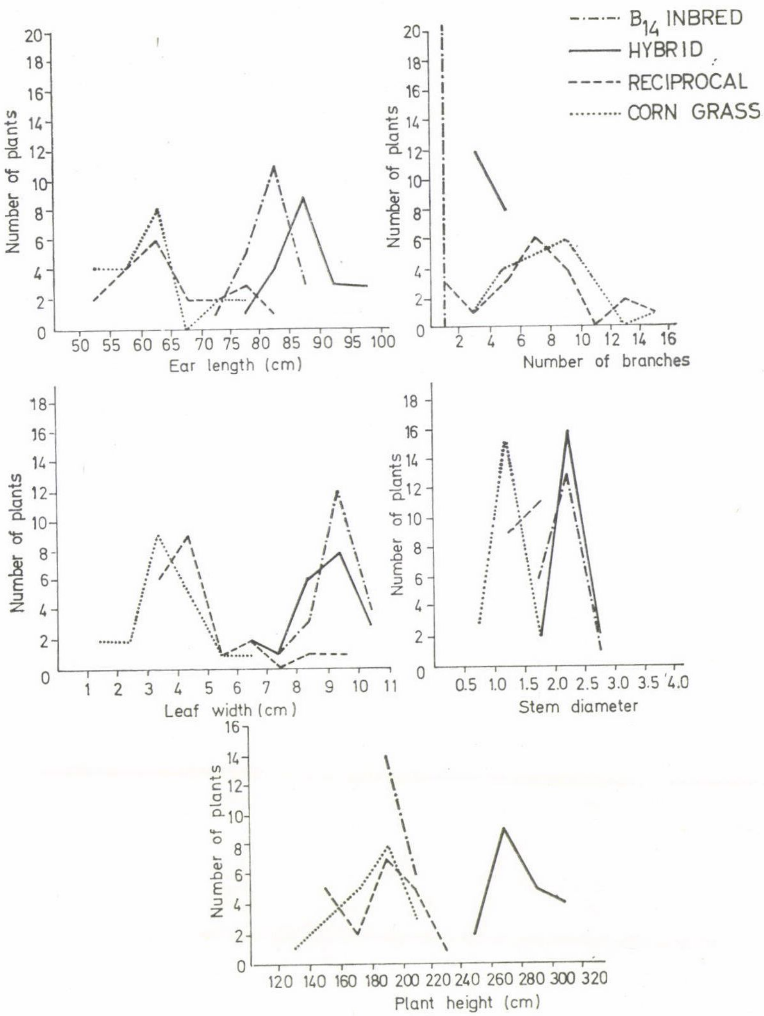


Fig. 4. Variations in vegetative characters in the parents, hybrid and reciprocal cross

significant differences between all the combinations, except between the corn grass and the reciprocal cross, which was not significant. For the number of tillers, the hybrid was intermediate between the parents, but in the other three characters the hybrid had the highest mean.

7. *Leaf width*,
8. *Number of rows*, and
9. *Ear length*. These three characters, when statistically analysed, gave highly significant differences between all combinations, except the comparison between the B_{14} inbred and the hybrid. The hybrid was intermediate between the parents in the number of ears, but it was greater for the other two characters.
10. *Number of rows*, and

11. *Ear diameter.* Highly significant differences between the hybrid and the parents were shown by an analysis of variance, and the hybrid was the highest for these two characters.
12. *Number of leaves under the ear.* There were significant differences between the hybrid and the "corn grass", but there was no significant difference between the hybrid and the B_{14} inbred.

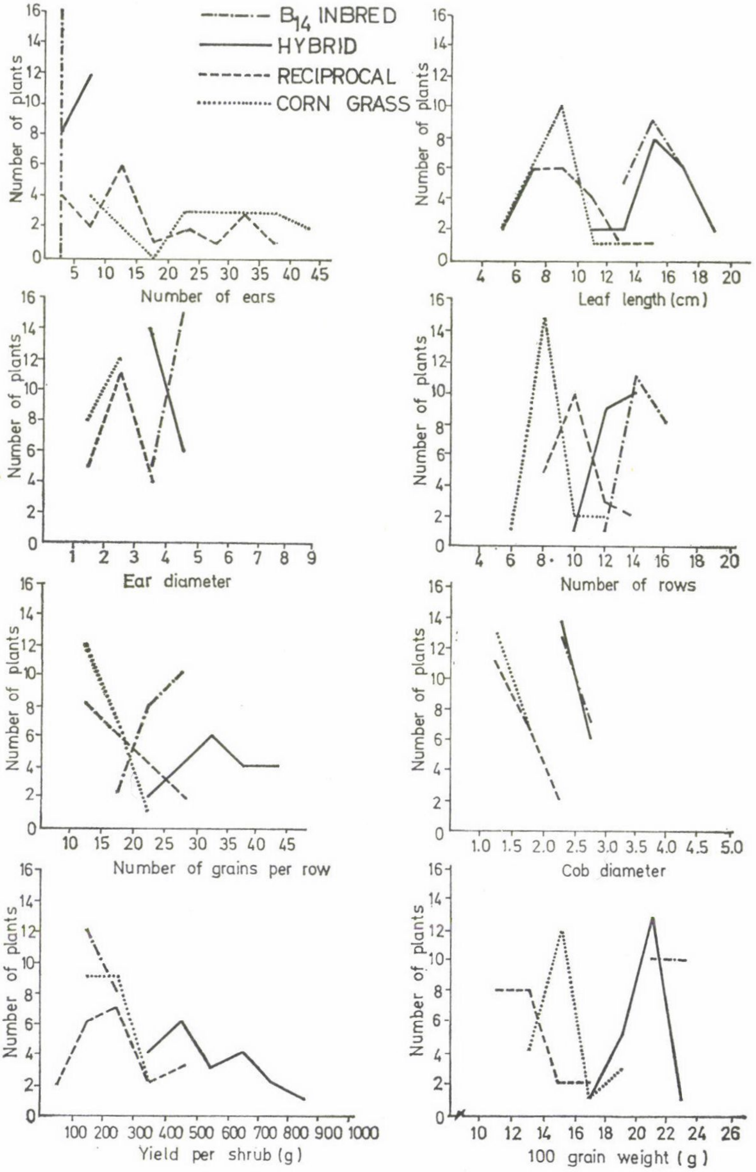


Fig. 5. Variations in yield and yield components in the parents, hybrid and reciprocal cross

13. *Number of leaves above the ear.* The analysis of variance showed that there was no significant difference between the hybrid and the two parents, but the difference was significant between the B_{14} inbred and the reciprocal cross, and highly significant between the "corn grass" and the reciprocal cross, and between the hybrid and the reciprocal cross.
14. *The main stem diameter.* From the analysis of variance the difference between the hybrid and the B_{14} inbred was not significant, but those between the hybrid and the "corn grass", and the hybrid and the reciprocal cross were highly significant. The hybrid was the highest.
15. *Number of tassel branches.* The analysis of variance showed highly significant differences between the parents and the reciprocal cross and between the hybrid and the parents. But the differences between the hybrid and the reciprocal cross and between the two parents were not significant.
16. *100-grain weight.* There was no significant difference between the hybrid and the B_{14} inbred, and between the "corn grass" and the reciprocal cross, but there were highly significant differences between all the other combinations.
17. *Analysis of amino acids.* Table 3 shows that the hybrid had the highest content of Glu, iLeu and Leu and was intermediate between the parents for Lys, His, Ser and Met.

A wide range of variation was observed in all the characters studied between the parents, the hybrid and the reciprocal cross. There was improvement of some characters in the hybrid, which could be utilized in economical production; for instance, plant height was about 3 m (Fig. 2), and the tillers and yield were highly significant. In the hybrid some characters were intermediate between the two parents, but in many characters the effect of the mother's cytoplasm was evident in the hybrid vigour; when the inbred line B_{14}, which has a high combining ability, was used as the mother in the hybrid, the yield was higher than in the reciprocal cross, when the macromutant "corn grass" was used as the mother. In Figs. 4 and 5 it is shown that the hybrid and the reciprocal cross were related to the mother.

*

Prepared at the Department of Plant Production, University of Agriculture, Debrecen.

H. Rabie, K. Pásztor

References

Andrianova, N. F. (1975): Breeding evaluation of quantitative characters in maize mutants in the Bukovina region. Kishinev, Moldavian SSR.

Bálint, A.—Sutka, J. (1966): Variability of quantitative characters in maize as affected by gamma irradiation. Acta Agron. Hung., **15**, 285—290.

Bálint, A.—Sutka, J.—Kovács, G. (1964): Comparative cytological and physiological examination of maize lines treated with irradiation and ethyl methane sulphonate. Biológiai Közlemények, **12**, 11—15.

Chkhikvadze, V. T. (1974): Maize mutants induced by chemical mutagens. Moscow, USSR.

Conger, B. V. (1976): Effectiveness of fission neutrons versus gamma radiation for inducing somatic mutations in presoaked seeds of maize. Mutation Research, **34**, 223—232.

Gavrilyuk, O. F. (1976): Characteristics of quantitative characters in branching forms of maize of the "corn grass" macromutation. Kishinev, Moldavian SSR, 56—61.

Ishalina, N. (1977a): Maize mutants induced by gamma irradiation of pollen. Tr., In., to botan., AN., Kaz., SSR, 122—129.

Ishalina, N. (1977b): Study of fifth generation of maize radiomutants. Tr. In. to botan., AN., Kaz., SSR.

Kasim, S. (1975): Experimental statistics. Dar El-Marif, Cairo.

Morgun, V. V.—Larchenko, E. A. (1975): The mutagenic effect of several nitroso compounds on maize. Khim. Supermutageny Selektsii. Moscow, USSR, 295—298.
Morgun, V. V.—Chuchmii, I. P. (1976): Genetic effect of different mutagenic forms in maize. Simpoz. p.s.-kh. radiobiol., Kishinev, Moldavian SSR, 136—137.
Poteknina, G. F. (1975): Variation in quantitative characters in midseason group of maize of the cultivated type obtained from the "corn grass" radiomutation. Kishinev, Moldavian SSR.
Tkachenko, V. D.—Baranova, A. S. (1975): Comparative study of the quantitative characters of single mutant hybrids from different types of cross. Kishinev, Moldavian SSR, Stiinca.

INFLUENCE OF SULPHATE IONS ON THE CHEMISTRY OF DIFFERENT SALTS IN SALT AFFECTED SOILS*

Salt affected soils may be found with a high diversity of physical, chemical and biological properties under a wide range of environmental conditions.

Salt affected soils may occur in closed basins, river deltas and terraces with a moderate climate in North and South America, Europe, Australia, Siberia and other places. Large areas of semiarid and arid regions are covered with soils having increased quantities of water soluble salts and/or poor water physical conditions (in the Near and Middle East, Central Asia, North Africa, etc.).

Some of these soils have poor fertility due to the toxic concentration of salts in soil solution. In other soils affected by salts the water uptake of the plants is restricted by unfavourable soil physical properties.

All these soils have the common feature that an increased amount of salt soluble in water plays a decisive role in their formation and the water soluble salts are directly or indirectly responsible for their low fertility.

The formation of salt affected soils is the result of two preconditions:

1. resources of soluble salts,
2. salt accumulation prevails periodically or permanently over leaching.

The formation and accumulation of salts are due to a large number of geochemical processes taking part in the upper strata of the earth's crust.

Salts soluble in water originate from two sources:

1. they may be of magmatic origin,
2. they can be formed by the weathering of crystalline rocks.

During the geological periods the magma forming processes and the volcanic and postvolcanic phenomena facilitated the accumulation of large quantities of chlorides, sulphates and borates in the solutions circulating on the earth and in the oceans, in continental and marine deposits. It is probable that the chlorides and sulphates in rocks, soils and oceans trace back, at least in part, to volcanic action.

In the recent period the weathering of rocks is the primary source of soluble salts entering into natural waters, sediments and soils. Rocks contain Ca, Mg, K and Na in the form of silicates. They rarely contain chlorides. Sulphur is usually present in the form of non-soluble sulphides, which may be transformed into sulphate due to the weathering and oxidation of volcanic and sedimentary rocks.

The geochemistry of the salts of a given place is determined by the mobility of the

* Lecture held at the Symposium on Land Reclamation in Iraq (Baghdad, 26—29 March, 1979).

compounds formed and by the sequence of precipitation of weathering products. The mobility of the rock forming elements depends on the following factors:

1. the stability of the crystal network
2. the radius of the ions formed during the weathering process
3. the valence of the ions formed during the weathering process.

These factors can be characterized by the coefficient of energy, which is the proportion of energy contributed by any ion (though at infinity) to the formation of a heteropolar combination. Fersman calculated the energy coefficients of single ions on the basis of the known lattice energies of inorganic salts. These values were called "experimental energy coefficients" and they should be considered as the most reliable ones. The Fersman's energy coefficients are closely related to the sequence of extraction of ions from minerals, to the rate of migration of ions and to their ability to accumulate in sediments and soils (Table 1).

Table 1

Sequence of ion-extraction during weathering
(according to Fersman)

Sequence of extraction	Ions	Coefficient of energy
I.	Cl^-, Br^-	0.23
	NO_3^-	0.18
	SO_4^{2-}	0.66
	CO_3^{2-}	0.77
II.	Na^+	0.45
	K^+	0.36
	Ca^{2+}	1.75
	Mg^{2+}	2.10
III.	SiO_3^{2-}	2.75
IV.	Fe^{3+}	5.15
	Al^{3+}	4.25

Table 2

Migration categories of elements
(after Polynov and Kovda)

1. Virtually non-leachable	Si from quartz
2. Slightly leachable	Fe, Al, Si
3. Leachable	Si, P, Mn
4. Highly leachable	Ca, Na, K, Mg, Cu, Co, Zn
5. Very highly leachable	Cl, Br, I, S, C, B

According to Fersman's categories the mobility of ions increases with a decrease in the energy coefficient of the ions and decreases with an increase in the ion radius and valence. In extreme cases the salts produced by the weathering of rocks may accumulate at the site of their formation. This is the case when the insufficiency of precipitation prevents them being removed to a distance. More frequently they are transported by natural water and redistributed. The distribution of the transported weathering products in a region is characterised by the sequence of migration categories of the elements (Table 2).

The absolute and relative participation of the elements in the formation of natural waters and saline soils are directly related to the categories which were determined empirically by Polynov and Kovda. The main compounds contributing to contemporary salt accumulation are the salts formed from the elements in the 4th and 5th migration categories. The type of salt accumulation depends on:

1. the quantity of water soluble salts
2. the chemistry of salinization
3. the vertical and horizontal distribution of accumulated salts in sediments and soils.

The climatic, geological, geomorphological and hydrogeological conditions are determining factors in the type and degree of salinization. Geomorphologically, salt accumulation is connected with the lowlands, or with parts of lowlands such as flood plains, deltas, low river terraces, lakes and coastal terraces.

In Figure 1 the distribution of continental sediments is given in relation with the geomorphology of the accumulation of different weathering products. The regions of salinization and of carbonate accumulation are clearly indicated.

From a hydrological point of view, the accumulation processes are usually related to regions with temporarily or permanently high water tables. Salt accumulation may often prevail where run-off is slight or virtually absent.

Climatic conditions where evaporation, either permanently or at least for some time, exceeds precipitation and run-off are favourable for salt accumulation. Due to the connection between climate and accumulation processes there is a zonal distribution in the mineralization degrees and types of natural waters, sediments and soils (Table 3).

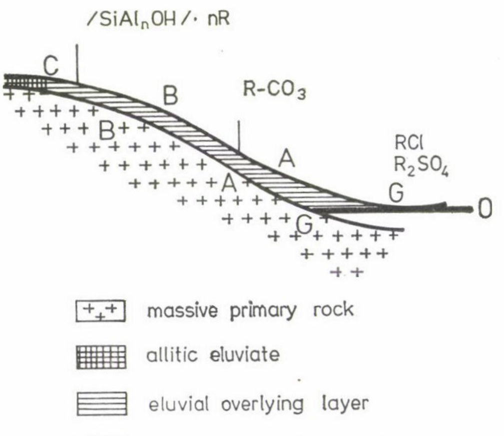


Fig. 1. Distribution of continental sediments. (G—O = level of catchment area; AA—GG = region of sulphate-chloride salinization; BB—AA = region of carbonate accumulation; C—BB = region of siallitic type of accumulation)

Table 3

Characteristics of accumulation processes in Eurasia in relation to natural conditions (after Kovda)

Conditions	Residual salinization of sedimentary rocks	Maximum mineralization of water: river (g/l)	ground (g/l)	lake (g/l)	Max. quantity of salts in surface horizons of solonchaks, %	Typical compounds	Salinization of irrigated soils
Deserts	common	20 —90	200—350	350—400	25 — 75	NaCl, $NaNO_3$ $MgCl_2$, $MgSO_4$ $CaCl_2$, $CaSO_4$	widespread
Semideserts	frequent	10 —30	100—150	300—350	5 — 8	NaCl, Na_2SO_4 $CaSO_4$, $MgSO_4$	often found
Steppes	rare	3 — 7	50—100	100—250	2 — 5	Na_2SO_4, NaCl Na_2CO_3, $NaHCO_3$	rarely found
Forest steppes	none	0.5— 1	1 — 3	10—100	0.5— 1	$NaHCO_3$, Na_2CO_3 Na_2SO_4, Na_2SiO_3	unknown
Forests	none	0.1— 0.2	0 — 1	none	none	R_2O_3, SiO_2	none

Table 4

Chemistry of gneiss, the weathered sediments of gneiss and the dry residual of the local river waters
(after Polynov)

	SiO_2	SO_4^{2-}	Cl^-	Ca^{2+}	Mg^{2+}	Na^+	K^+	Al_2O_3	Fe_2O_3
	%								
Primary rock (gneiss)	64.1	0.26	0.04	0.64	1.10	1.20	2.67	20.35	6.97
Weathered sediment of primary rock	60.1	0.22	0.04	0.38	1.31	1.12	2.65	20.17	8.55
Dry residual of river waters	21.3	36.7	trace	13.00	2.80	7.8	Ø	3.6	Ø

13*

Regarding the mineralization of natural waters in Eurasia, the salt concentration of river waters amounts to 0.1—0.2 g/l in the forest zone, which increases up to 20—90 g/l in the desert with the increase in aridity. The stagnant waters of lakes are mineralized more than the river waters in the same region. In desert and semidesert regions the mineralization in the water of lakes reaches 300—400 g/l. The chemical composition of accumulated salts changes parallel with the increase in mineralization.

While in cases of a comparatively low degree of mineralization the accumulation of carbonate-bicarbonate salts prevails, with an increase in mineralization the carbonate-sulphate and chloride-sulphate types of salt accumulation will be dominant.

In the course of the development of soil science and soil classification two main groups of salt-affected soils have been distinguished:

1. Soils affected by salts dissociating with a neutral reaction, mainly sodium chloride and sodium sulphate.

2. Soils affected by sodium salts capable of alkaline hydrolysis, mainly by sodium carbonate, sodium bicarbonate and sodium silicate.

Besides these two main groups the following types of soils belong to salt affected soils:

a) Gypsiferous soils. In these soils the high $CaSO_4$ content causes salinity. These kinds of soils occur in several areas with arid and semiarid conditions (i.e. the Middle East, North Africa, Central Asia, etc.).

b) Salinity caused by calcium chloride. Similar to group "a", but it occurs more seldom under arid conditions.

c) Salinity caused by magnesium salts. This group occurs under various environmental conditions. This type of salinity is mentioned only vaguely in technical literature.

d) Acid sulphate soils occur on the coastal regions of practically all continents, on clayey sediments, under brackish to saline conditions. They form during the aeration of piritic sediments in the swampy coastal area in the absence of sufficient neutralizing substances such as calcium carbonate.

Although it is evident that semiarid and arid regions are the typical areas of sulphatic salinization, sulphates may accumulate in soils under different climatic conditions.

The mobility of different sulphate salts and their role in the formation of salt affected soils are very diverse. The influence of sulphates on soil properties and plant growth depends mainly on the kind of cation to which the sulphate is bound.

Discussing the influence of sulphate salts on soil properties we may distinguish:

I. the evaluation of sulphate sources

II. the description of the solubility of sulphate compounds

III. the discussion of the effect of sulphate salts on the physical and physico-chemical properties of soils and the characterization of the toxicity of sulphate compounds to plant growth.

I

The evaluation of sulphate sources

The sulphate compounds in natural waters, sediments and soils are mainly weathering products of the minerals of volcanic and sedimentary rocks, as can be seen in Table 4.

Calcium sulphate occurs in natural waters, sediments and soils of all regions with different climatic conditions as a product of the weathering of sulphide minerals, due to the reaction of sulphate ions with calcium removed from the calcium bearing minerals.

Calcium sulphate also accumulates secondarily by the reaction of sodium sulphate and calcium chloride in sediments and soils. In semiarid and arid regions the sediments and rocks contain large quantities of calcium sulphate, precipitated during the evaporation of saline lacustrine waters and ground waters.

Calcium sulphate accumulates in the soil under various climatic conditions, in various soil horizons and in various quantities and forms.

Usually, in the soils of the moderate climatic belt, calcium sulphate accumulates in the "B"$_2$ horizon of hydromorphic soils, as for instance in meadow solonetz, solonetz-like meadow soils and meadow soils.

In Table 5 this phenomenon is demonstrated in the hydromorphic soils of the Hungarian Lowland.

Table 5

The chemical composition of saturation extracts of hydromorphic soils in Hungary

Soil	Depth of sampling, cm	Soluble salts, %	Ca^{2+}	Mg^{2+}	Na^{+}	HCO_3^-	Cl^-	SO_4^{2-}
			me/l					
Meadow soil	7— 17	0.10	5.25	0.98	0.87	0.64	3.90	0.55
	58— 72	0.30	14.80	12.60	6.10	1.46	12.80	6.60
	90—110	0.35	22.50	12.10	4.80	0.88	5.30	27.00
	126—136	0.22	17.80	9.80	7.60	1.00	5.60	22.90
Solonetz-like	5— 17	0.01	2.40	2.80	0.97	0.25	2.00	0.50
meadow soil	30— 42	0.06	2.50	5.30	1.60	3.00	2.50	1.30
	56— 76	0.10	3.75	3.60	1.60	1.60	0.72	2.60
	89—100	0.55	17.40	16.00	21.30	1.40	1.10	31.40
Meadow solonetz	8— 16	0.06	4.30	6.00	6.40	3.10	4.40	1.40
	26— 37	0.12	4.50	3.70	10.00	3.50	3.40	4.30
	45— 55	0.20	40.0	3.40	18.20	4.80	4.60	4.10
	75— 85	0.75	15.10	41.70	37.70	1.50	1.70	37.80
	97—105	0.75	15.50	34.80	34.30	1.40	1.30	43.50
	117—126	0.25	3.10	8.30	24.50	3.30	2.70	8.30

Table 6

Chemical composition of the soluble salts in meadow solonchak in north Kysil-Kum Desert, determined from 1 : 5 water extracts
(after V. M. Borovski)

Profile No.	Depth of sampling, cm	Dry residual	HCO^-	CO_3^{2-}	Cl^-	SO_4^{2-}	Ca^{2+}	Mg^{2+}	$Na^+ + K^+$
			%						
3271	0— 2	21.73	0.04	traces	1.85	11.36	2.63	0.36	5.68
	2— 6	16.00	0.04	traces	1.46	8.62	2.52	0.33	4.18
	10— 15	4.41	0.02	Ø	1.05	1.61	0.33	0.18	0.74
	25— 30	3.52	0.02	Ø	1.09	1.04	0.11	0.16	0.79
	40— 45	3.23	0.01	Ø	0.89	1.04	0.13	0.12	0.71
	120—125	1.24	0.01	Ø	0.20	0.58	0.12	0.04	0.19
	190—195	1.94	0.02	Ø	0.18	1.04	0.18	0.05	0.32

Table 7

The chemical composition of saturation extracts of

Depth of sampling, cm	Ca^{2+}		Mg^{2+}		Na^{+}	
	1	2	1	2	1	2
	$10^3 \cdot$ mol/l					
40– 60	8.42	11.5	16.7	13.5	97.8	90.6
60– 80	1.80	12.1	4.1	4.1	63.0	59.3
80–100	1.90	12.3	4.2	4.5	63.0	49.8
100–120	1.40	12.5	2.20	2.1	43.5	39.5
120–140	1.40	12.0	1.60	2.7	37.0	33.3

1. Before saturating with gypsum. 2. After saturating with gypsum.

Calcium sulphate often occurs in the deeper layers of the soils of the steppe region and calcium sulphate may be found in high amounts in the gypsiferous soils of deserts and semideserts.

In Table 6 the chemical composition of the soluble salts in a meadow solonchak in the Kyzil-Kum Desert shown.

Calcium sulphate usually occurs in soils as gypsum. Gypsum crystallizes in soils in a great variety of forms, from thin transparents to large nodules, concretions or regularly shaped slabs. Gypsum sometimes forms a spongy porous mass in soils, causing cementation in the horizon of accumulation on the surface, or in the entire soil profile. Under the very dry climate of deserts the gypsum may be dehydrated and turn into a dry powdery mass of calcium sulphate hemihydrate.

Magnesium sulphate, which has high solubility, is mainly a product of weathering. It is a typical component of sea water, occurs in saline ground waters, in many saline lakes, and accumulates in the form of epsomite ($MgSO_4 \cdot 7H_2O$) in the saline soils of desert and semidesert regions. Magnesium sulphate never accumulates in soils in the pure form, but may always be found together with other easily soluble salts, such as sodium sulphate, sodium chloride and magnesium chloride.

Sodium sulphate is mainly a weathering product, with high solubility and high mobility. High concentrations of sodium sulphate may occur in saline ground waters, in the water of saline lakes and in sea water. Sodium sulphate can be found in the salt affected soils of the steppe region, but it is a typical compound in the saline soils of desert and semidesert regions. Depending on the temperature, sodium sulphate crystallizes with a different number of water molecules. On the surface of solonchak soils, at relatively low temperature, it precipitates in the form of large transparent mirabilite ($Na_2SO_4 \cdot 10\,H_2O$), which, with an increase in temperature and a decrease in humidity, dehydrates and turns into white powdery thenardite (Na_2SO_4).

II

The solubility of sulphate compounds

The sulphate compounds taking part in the formation of salt affected soils have very different solubilities. The concentrations of saturated solutions of gypsum, magnesium sulphate and sodium sulphate at 25 °C are: 2 g/l, 262 g/l, and 280 g/l, respectively.

solonetz soil before and after saturating with gypsum

SO_4^{2-}		HCO_3^-		Cl^-		"I"	
1	2	1	2	1	2	1	2
$10^3 \cdot$ mol/l							
65.8	63.9	0.87	1.33	14.7	13.8	238.6	230.5
31.7	39.6	1.71	1.48	12.4	11.4	113.7	147.6
31.6	38.9	0.95	2.14	13.8	12.7	114.2	143.9
17.7	29.5	1.1	1.62	12.2	11.2	71.0	115.0
15.3	25.8	0.67	1.08	11.4	10.7	51.0	103.5

The solubility of calcium sulphate: The saturation concentration of gypsum in water is rather low. The solubility of calcium sulphate depends on the ionic concentration and the composition in the case of a mixed salt solution. The amount of gypsum dissolved at saturation concentration can be calculated from:

a) the thermodynamic solubility product of $CaSO_4 \cdot H_2O$,

b) the total ionic concentration of the solution to be saturated for gypsum,

c) the ionic composition of the solution before saturating with gypsum.

The solubility product of a salt calculated from the concentrations of the related ions depends on the ionic concentration and ion composition of the electrolyte. The thermodynamic solubility product which is calculated from the activities of the ions and takes into account the electrostatic interaction of particles with opposite charges remains constant in electrolytes having different concentrations and different compositions.

Saturation extracts from solonetz soils were prepared and analysed before and after saturating with calcium sulphate (Table 7). The solubility products (thermodynamic solubility products) were calculated with and without subtracting the sum of the ion-pair concentrations from the analytical concentrations of calcium and sulphate ions.

It is evident, that the ability to form ion-pairs depends on the valences and sizes of the ions.

The solubility products of gypsum (Table 8) depend on the ionic concentration of the solution calculated either from the analytical concentrations of calcium and sulphate or by reducing the ion concentrations by the sum of the ion-pair concentrations. The thermodynamic solubility product changes only slightly with the change of ionic concentration in the solution and it is independent of the electrolyte concentration if the thermodynamic solubility product is calculated from the reduced activities of calcium and sulphate ions.

The solubility of calcium sulphate is higher in the soil solution when the concentration of non-sulphate electrolytes increases. In a solution containing sodium sulphate and/or magnesium sulphate the dissolution of calcium sulphate is limited by the concentration of sulphates.

In systems containing solid calcium carbonate and calcium sulphate the ratio of the amounts of $CaSO_4$ and $CaCO_3$ dissolved must be determined by the ratio of their thermodynamic solubility products, according to the following equation:

$$\frac{K_{SPCaSO_4}}{K_{SPCaCO_3}} \cong 5\ 10^3 \qquad \text{(at 25 °C)}$$

K_{SP} = thermodynamic solubility product.

For the sulphate type of salinization the solubility of calcium sulphate decreases with an increase in the sulphate concentration of the soil solution and the dissolution of $CaCO_3$ in-

Table 8

The solubility product of gypsum calculated from the concentration and ionic activities of soil saturation extracts saturated with $CaSO_4$

Ionic strength of the solution		Solubility product calculated from		Thermodynamic solubility product calculated from	
total	reduced	total	reduced	total	reduced
in 10^3 mol/l		ion concentrations		ion activities	
230.5	170.7	$7.33 \cdot 10^{-4}$	$2.92 \cdot 10^{-4}$	$5.81 \cdot 10^{-5}$	$2.85 \cdot 10^{-5}$
147.6	114.0	$4.78 \cdot 10^{-4}$	$2.12 \cdot 10^{-4}$	$5.19 \cdot 10^{-5}$	$2.74 \cdot 10^{-5}$
143.9	109.9	$4.80 \cdot 10^{-4}$	$2.12 \cdot 10^{-4}$	$5.39 \cdot 10^{-5}$	$2.81 \cdot 10^{-5}$
114.5	89.3	$3.69 \cdot 10^{-4}$	$1.72 \cdot 10^{-4}$	$4.76 \cdot 10^{-5}$	$2.62 \cdot 10^{-5}$
103.5	78.9	$3.10 \cdot 10^{-4}$	$1.46 \cdot 10^{-4}$	$4.28 \cdot 10^{-5}$	$2.39 \cdot 10^{-5}$
				$\overline{K}_{sp} = 5.07 \cdot 10^{-5}$	$2.68 \cdot 10^{-5}$
				$\overline{S} = 2.59 \cdot 10^{-6}$	$8.24 \cdot 10^{-7}$
				CV = 11.4%	6.87%

Table 9

Chemical composition of saturation extracts after treatment with $CaSO_4$ anhydrite

Depth of sampling, cm	"pH"	Ca^{2+}	CO_3^{2-}	HCO_3^-	SO_4^{2-}	"I" $10^3 \cdot$ mol/l	Thermodynamic solubility product	
		me/l					$CaSO_4$	$CaCO_3$
2—8	8.25	39.75	2.06	6.54	141.30	266.3	$4.635 \cdot 10^{-5}$	$2.2346 \cdot 10^{-8}$
8—17	8.10	29.01	2.16	3.79	139.30	251.0	$3.582 \cdot 10^{-5}$	$0.7867 \cdot 10^{-8}$
17—32	8.13	29.68	1.26	3.64	154.67	272.9	$3.743 \cdot 10^{-5}$	$0.8906 \cdot 10^{-8}$
32—42	7.85	29.42	1.34	3.52	140.24	250.9	$3.631 \cdot 10^{-5}$	$0.2544 \cdot 10^{-8}$
42—63	7.75	30.19	1.18	3.34	100.24	180.1	$3.520 \cdot 10^{-5}$	$0.1916 \cdot 10^{-8}$
63—79	7.80	34.42	0.98	1.99	70.90	136.3	$3.703 \cdot 10^{-5}$	$0.3251 \cdot 10^{-8}$
79—90	7.75	35.65	0.59	2.21	63.40	124.8	$3.725 \cdot 10^{-5}$	$0.2839 \cdot 10^{-8}$
							$\overline{X} = 3.791 \cdot 10^{-5}$	$\overline{X} = 0.7096 \cdot 10^{-8}$
							$S = 3.81 \cdot 10^{-6}$	$\overline{S} = 0.2747 \cdot 10^{-8}$
							$\overline{S} = 1.44 \cdot 10^{-6}$	
							CV = 9.74%	

$$\lg K_{CaCO_3} = \lg (Ca^{2+}) + 2\,pH + \lg [K_1 \cdot K_2 (H_2CO_3)]$$
$$\lg_{CaSO_4} = \lg (Ca^{2+}) + \lg (SO_4^{2-})$$

creases due to the increasing ionic concentration. The dissolution of calcium carbonate shifts the pH value of the media towards the alkaline reaction.

Saturation extracts prepared from solonetz soils containing $CaCO_3$ were saturated with calcium sulphate and analysed as to their chemical composition (Table 9). The data of analyses indicate clearly that the carbonate concentration, the total alkalinity and the pH value of the extract increase parallel with the increasing sulphate concentration.

The increase in the sulphate concentration stabilizes the calcium concentration of a solution saturated with calcium sulphate at a certain level.

The thermodynamic solubility product of $CaSO_4$ was calculated from the reduced activities of calcium and sulphates ions. The reduced activities of the ions were calculated by subtracting the sum of the ion-pair concentrations from the analytical concentrations of the relevant ions and multiplying with the coefficients of activities from the enlarged equation of Debye—Hückel:

$$-\log \gamma = \frac{Az^2 \sqrt{I}}{1 + Bv\sqrt{I}}$$

A and B = constants
l = ionic concentration of the solution mol/l
z = valence of the ion
v = diameter of the hydrated ion Å
γ = coefficient of activity

The average thermodynamic solubility product of calcium sulphate anhydrite is 3.79×10^{-5}, the standard deviation of the mean is 1.44×10^{-6} and the coefficient of variation amounts to 9.74%. The thermodynamic solubility product in the extracts investigated does not show any dependence on the concentration of the solution. The thermodynamic solubility product of calcium carbonate was calculated from the reduced activitv of calcium ion and the pH value of the solution:

$$\lg K_{SP} = \lg K_1K_2(H_2CO_3) + pH + \lg (Ca^{2+})$$

K_1 and K_2 = the first and second dissociation constants of H_2CO_3

K_{SP} = thermodynamic solubility product of $CaCO_3$

(Ca^{2+}) = activity of related ion compound.

The average thermodynamic solubility product is 0.7096×10^{-8}

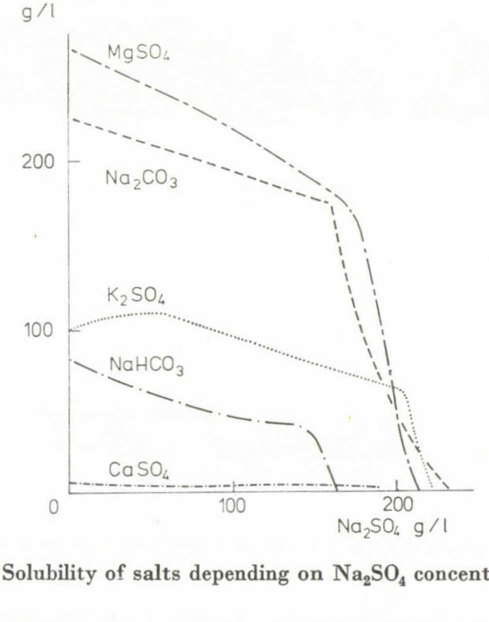


Fig. 2. Solubility of salts depending on Na_2SO_4 concentration

The standard deviation of the mean amounts to 0.2747×10^{-8}.

The solubility of magnesium sulphate: this is very good in water and depends only slightly on the temperature. The saturating concentration of magnesium sulphate decreases with increasing sodium sulphate concentration (Fig. 2).

Magnesium sulphate has high mobility as a result of its high solubility.

The solubility of sodium sulphate: sodium sulphate has high solubility in water. The dissolution of this salt depends very much on the temperature and it increases considerably if the temperature rises. In the case of sodium sulphate salinization the situation is rather complex. In the warm dry season of the year sodium sulphate accumulates together with other easily soluble salts on the surface of soils. In the cold rainy period the solubility of sodium sulphate decreases and it is not leached.

III

Discussion of the effect of sulphate salts on the physical and physico-chemical properties of soils and the characterization of the toxicity of sulphate compounds to plant growth

The influences of different sulphate compounds on the soil properties and plant growth are rather different and they are determined by the solubility of the salts, and the valence and size of the cation of the sulphates.

Calcium sulphate may accumulate in large amounts in soils, but it has no toxic effect on the plants due to its low solubility.

The compact layer of gypsum accumulation on the surface or in the root zone of soils may be impenetrable by water, air and plant roots and it may have an adverse effect on the plants. The calcium ion of calcium sulphate reacts with sodium salts capable of alkaline hydrolysis and with the exchangeable sodium in the soil. If gypsum is present in the soil it neutralises the sodium salts capable of alkaline hydrolysis, forming poorly soluble salts with the anion of the weak base, while the cation forms salts dissociating with a neutral reaction. The calcium ion of calcium sulphate replaces the exchangeable sodium according to the extent of decrease in the sodium adsorption ratio in the equilibrium solution (Table 10).

If the sulphate type of salinization occurs, the leaching of sodium sulphate causes an

Table 10

SAR values and sodium saturation percentages of soils before and after treatment with calcium sulphate

Depth of sampling, cm	SAR		ESP		Δ SAR	Δ ESP
	1	2	1	2		
2–8	31.6	23.7	31.2	25.2	7.9	6.0
8–17	53.4	27.5	43.7	28.2	25.9	15.5
17–32	69.6	35.0	50.3	33.5	34.5	16.8
32–42	65.6	32.4	48.8	31.7	33.2	17.1
42–63	73.0	20.9	51.6	22.9	52.1	28.7
63–79	39.5	10.4	36.3	12.3	29.1	24.0
79–90	38.4	7.1	35.6	8.5	31.2	27.2

1. Before treatment with calcium sulphate.
2. After treatment with calcium sulphate.

increase in the solubility of calcium sulphate and this phenomenon promotes the ameliorative effect. Gypsum and other materials containing calcium sulphate are widely used for the reclamation of sodic and alkali soils. The influence of magnesium ion on the soil properties and plant growth is rather diverse and it depends on the form and quantity of magnesium accumulated in the soil.

Magnesium sulphate may accumulate in soils in large quantities. A solution with a high concentration of magnesium ions is one of the most toxic and harmful agents for plants.

An increase in the magnesium ion concentration in the soil solution during the accumulation period leads to an increase in the magnesium saturation of the soil and to an increase in the magnesium adsorbed by soil minerals. The cations of the soil solution among the magnesium ions may adsorb on the clay minerals by ion exchange or they may enter the crystal lattice of the layer silicates or possibly combine with other products of weathering to form clay minerals. Heavy textured soils with an increased amount of easily soluble magnesium salts and/or a high degree of magnesium saturation often contain layer silicates rich in magnesium. The degree of magnesium adsorption and desorption are determined by:

a) the equilibrium between the cations of intermicellar and micellar solutions

b) the equilibrium between the cations of the crystal lattice of the mineral and the micellar solution.

During the accumulation period the magnesium sulphate accumulates together with other easily soluble salts, mainly with sodium salts. An increase in sodium and magnesium ion concentration in the solution raises the sodium and magnesium saturation of the soil and the ratio of layer silicates rich in magnesium. If the leaching process takes place the soluble salts are leached out according to their mobility. The degree of sodium saturation decreases proportionally with the change in the concentration and chemistry of the soil solution. Some of the exchangeable magnesium may enter the liquid phase too, but it is recharged by the magnesium ions entering from the crystal lattice in exchangeable position. According to our present knowledge different types of "magnesium soils" may be distinguished.

a) Magnesium or magnesium-sodium solonchak

b) Heavy textured meadow soils with poor water-physical properties

c) Residual solonetz soils with the morphological features of solonetz soils, having a high degree of magnesium saturation but a low degree of sodium saturation.

Sodium sulphate accumulates in soils under different climates in different quantities. In the desert and semidesert regions it is a typical compound of the salts accumulated in saline soils as might be expected from its high mobility. The toxicity of sodium sulphate is two or three times less than that of magnesium sulphate and it is two or four times less than the toxicity of sodium chloride. In a sodium sulphate type of salt accumulation an increase in the salt concentration and the sodium adsorption ratio in the soil solution shifts the ion exchange equilibria in favour of the sodium ions and the degree of sodium saturation of the soil increases with the increasing salt accumulation.

Comparing the equilibrium conditions in systems containing sodium chloride and sodium sulphate the degree of sodium saturation of the adsorbent differs as much as the coefficient of activity of the chloride and sulphate ions under the same conditions. In soils containing sodium sulphate and calcium sulphate, the degree of sodium saturation increases parallel with the increase in the sodium sulphate concentration.

Sulphate solonchaks usually contain Na_2SO_4 and $MgSO_4$. They occur mainly in continental depressions in the semidesert and desert regions. They have favourable water physical properties. The sulphate solonchaks can be ameliorated easily and rapidly by leaching and drainage, as a result of their natural gypsum content and high water permeability. The leaching has to be carried out in the warm period if the main compound among the sulphates is the sodium sulphate, to avoid the decrease in salt solubility with the decrease in temperature.

Table 11

Classification of saline soils by degree and type of salinity in relation to field crops

Condition of agricultural crops with medium salt resistance	Degree of soil salinity	Type of salts dominating in soils						
		Soda	Chloridic soda and soda chloridic	Sulphatic soda and soda sulphatic	Chloridic	Sulphatic Chloridic	Chloridic Sulphatic	Sulphatic
		Content of salts soluble in water in the horizon of maximum salt accumulation within the stratum 0—60 cm (as %)			Content of salts soluble in water on average, for the 0—100 cm stratum (as %)			
Good growth and development (no bare patches, crop normal)	Practically non-saline (or only very slightly saline)	0.10	0.15	0.15	0.15	0.20	0.25	0.30
Slight withering (bare patches and decrease of crop by 10—20%)	Slightly saline	0.10—0.20	0.15—0.25	0.15—0.30	0.15—0.30	0.20—0.30	0.25—0.40	0.30—0.60
Medium withering (bare patches and decrease of crop by 20—50%)	Medium saline	0.20—0.30	0.25—0.40	0.30—0.50	0.30—0.50	0.30—0.60	0.40—0.70	0.60—1.0
Marked withering (bare patches and decrease of crop by 50—80%)	Strongly saline	0.30—0.50	0.40—0.60	0.50—0.70	0.50—0.80	0.60—1.0	0.70—1.20	1.0 —2.0
A few scattered plants survive (virtually no crop)	Solonchaks	>0.50	>0.60	>0.70	>0.80	>1.0	>1.20	>2

In chloride-sulphate and sulphate-chloride types of salinization chloride and sulphate salts accumulate together. The method of amelioration is nearly the same as that for sulphate solonchaks. The maximum permissible level of salt content and the desired degree of leaching are different because of the different toxicity of chloride and sulphate ions (Table 11).

In sulphate-carbonate salinization the sulphate ions dominate in the soil solution but the presence of carbonate ions shifts the reaction of the media to the alkaline range, increases the toxic effect of the salts on the plants and raises the dispersion of soil particles, causing poor hydrophysical properties. The amelioration of soils formed by the influence of sulphate soda-salinization is carried out by the use of chemicals in combination with drainage and leaching.

I. Szabolcs, K. Darab
Research Institute for Soil Science and Agricultural Chemistry
of the Hungarian Academy of Sciences,
Research Institute for Water Resources,
Budapest

WINTER HARDINESS — FROST RESISTANCE*

Winter hardiness is a hereditary character, which is generally associated with winter habit but is not exclusively a property of winter wheat. There exist, for example, intermediate wheats, which are actually frost resistant spring wheats and can be sown in autumn or spring alike.

The winter hardiness of winter wheats is generally most pronounced in that stage of ontogenesis when the vernalisation period is not yet finished. In addition, it depends on the current state of hardening. This explains why the resistance of hereditarily winter hardy varieties is not always expressed to the same extent but varies from year to year, depending on a number of factors (sowing time, supplies of water, nitrogen and phosphorus, etc.). Thus, the development of winter hardiness is considerably influenced by the environment. This is the reason for the varying winter hardiness of certain wheats not only in different years but also in the course of any given year.

Frost resistance is part of winter hardiness but is not identical with it, since in winter the plants are also exposed to other stress factors apart from frost (wind, snow, rain, hail, withering, etc.), but these effects are also induced mainly by reduced temperature. This is why those wheats which withstand frost usually survive the winter too, which means that frost resistance is a reliable indication of winter hardiness.

Under the weather conditions experienced in the Carpathian Basin, concessions with respect to frost resistance and winter hardiness cannot be made with impunity, because in this region the weather is very variable and mild winters are often followed by severe ones, as is well illustrated by the mean December, January, February and March temperatures over many years (Figs. 1—4). A number of mild winters in succession, as has been experienced for the most part in the seventies, may lead to the nurseries of winter cereal breeders becoming dominated by lines which may be completely destroyed by the following hard winter. In order to counteract this, efforts have been made at Martonvásár to elaborate a test, with the help of which the frost resistance of winter wheat breeding stock can be reliably determined independently of the external weather fluctuations. This was facilitated by the establishment of a phytotron in the institute at the end of 1972. The method basically consists of raising,

* Address presented as FAO consultant in Poland, autumn 1979.

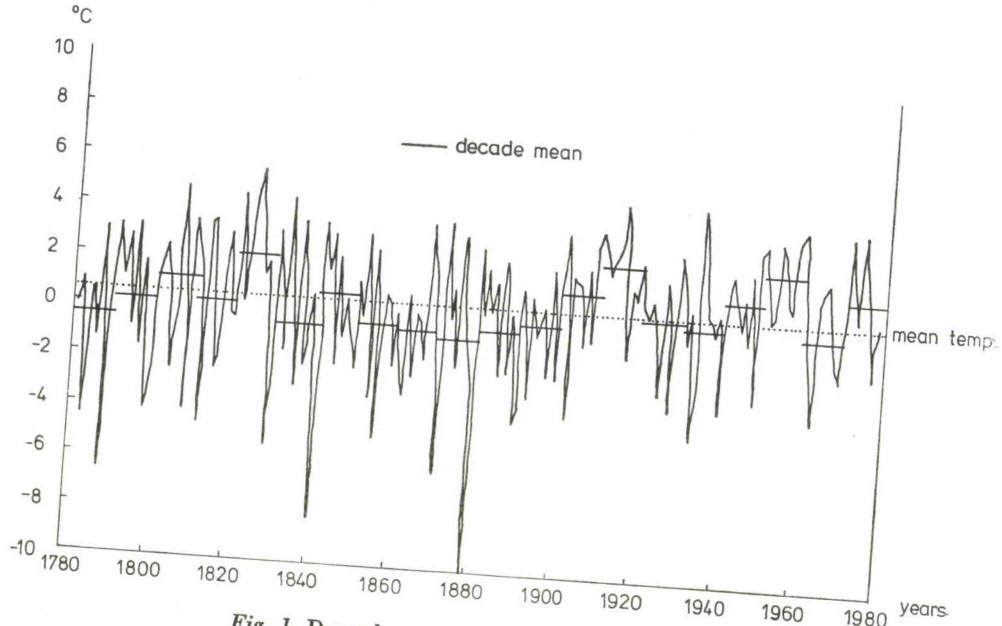


Fig. 1. **December mean temperatures (1781—1978)**

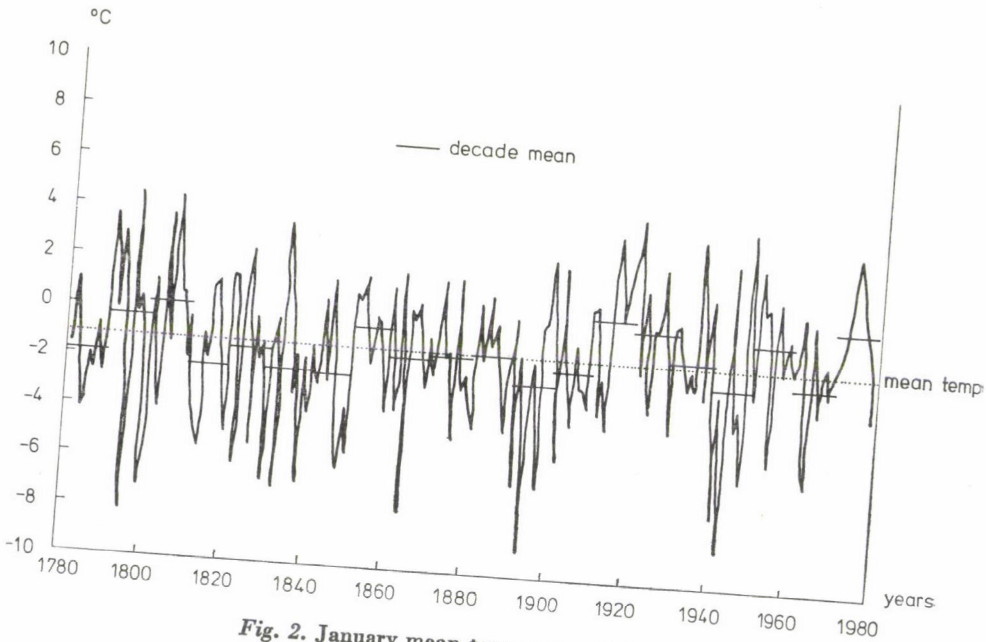


Fig. 2. **January mean temperature (1781—1979)**

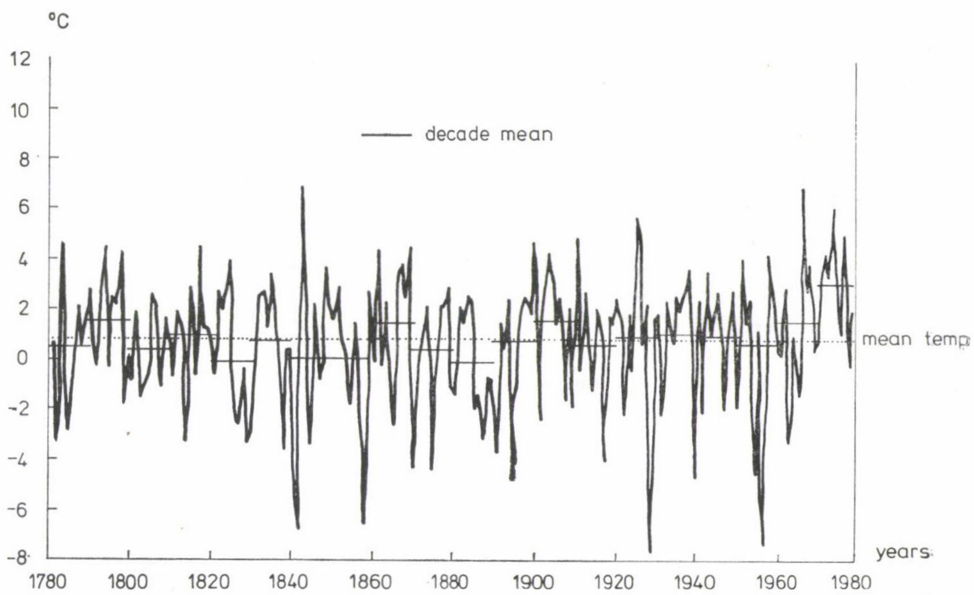


Fig. 3. **February mean temperature (1781—1979)**

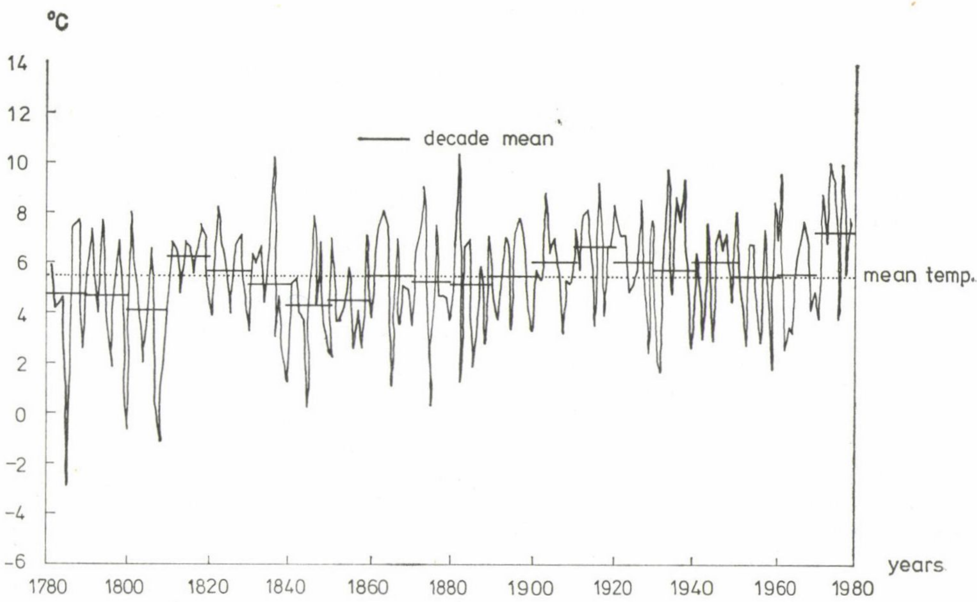


Fig. 4. **March mean temperature (1781—1979)**

hardening, freezing and thawing the experimental plants and determining the frost resistance on the basis of the extent of regrowth, all in a reproducible environment in the phytotron, throughout the year.

Materials, methods, results and evaluation per experiment

Hundreds and thousands of new Martonvásár wheat lines produced by the winter wheat breeding team, and the combinations originating from hybrid wheat research, have been examined in the phytotron since the end of 1972. The frost resistance tests carried out for Martonvásár and non-Martonvásár programmes alike are part of the phytotron's contribution to genetical, cytological and biochemical research. Right from the start, the frost resistance tests have been linked with methodological experiments in order to perfect the testing method (Åkerman—Lindberg 1927, Tumanov 1935). These methodological experiments were aimed mainly at optimising the raising, hardening and freezing of the plants and can be summarised as follows.

Experiment 1

The first methodological experiment was set up in 1972/73, when the phytotron went into operation, and was arranged as follows:

1.1 Plants grown and frozen in the phytotron

1.2 Plants grown in the open and frozen in the phytotron

1.3 Plants grown in the phytotron and overwintered in the open

1.4 Plants grown and overwintered in the open.

Germinated seeds were sown in mid-October 1972 in $42\times30\times14$ cm wooden boxes filled with black soil rich in humus. Each box contained 9 rows of 20 plants each. Of the nine varieties examined a different variety was sown in each row in a random arrangement, generally in four series, i.e. in four boxes, repeated as many times as was necessary for all the variants. Two of the varieties examined, Mironovskaya 808 and Bezostaya 1, were hardy winter wheats; Bezostaya 1 was the Hungarian standard at the time. Other characteristic varieties were the slightly hardy Italian winter wheat Libellula, the French winter wheat Etoile de Choisy which was approximately intermediate in hardiness between Bezostaya 1 and Libellula, and two Mexican spring wheats, Penjamo 62 and Siete Cerros.

About half the boxes (variants 1.2 and 1.4) were left in the open and the other half (variants 1.1 and 1.3) were placed in three PGV phytotron units. Different autumn climatic programmes were set up in each unit for raising the plants. In the spirit of our phytotron research strategy (Rajki 1973) the climatic programmes (Fig. 5), which simulate nature, were constructed by our meteorologist colleagues (Pletser 1973) to satisfy the needs of the experiment and were based on meteorological data collected over 40 years. The programmes simulated conditions beginning in the first week of September (S), October (O) or November (N) and each lasted 7 weeks. The daily rhythm of temperature and light intensity for each week of one of the climatic programmes (N) can be seen in Fig. 6.

The developmental stage of the shoot apex was determined at the end of raising for plants grown in the phytotron and at the end of the autumn for those raised in the open.

Each of the S, O and N raising programmes was followed by a two-phase hardening period, the first phase of which was carried out in the PGV unit. The temperature fluctuated daily between +3 and —3 °C, with an illumination intensity of 15,000 lux for 21 hours. Immediately prior to freezing the second phase of hardening, lasting 4 days, was carried out in the C unit used for freezing. In this phase a temperature of —4 °C was programmed without illumination.

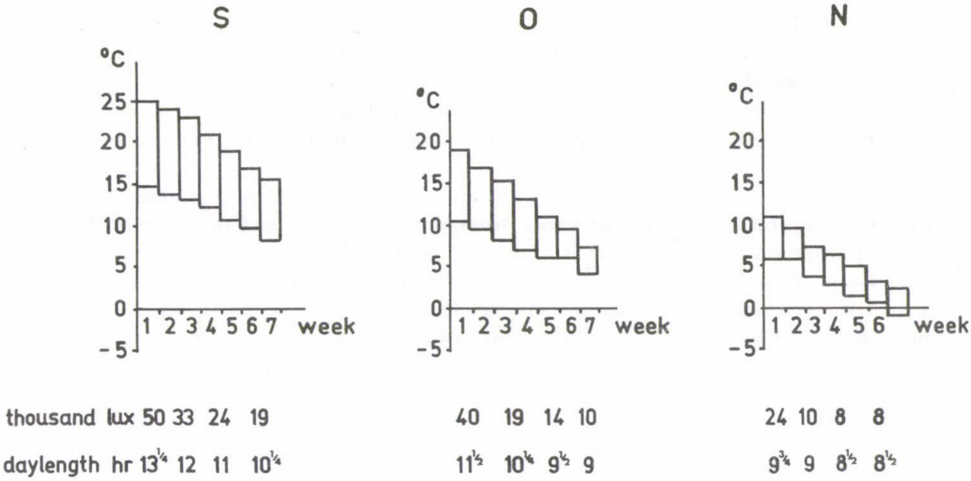


Fig. 5. **Temperature, light intensity and daylength for various programmes in the phytotron**

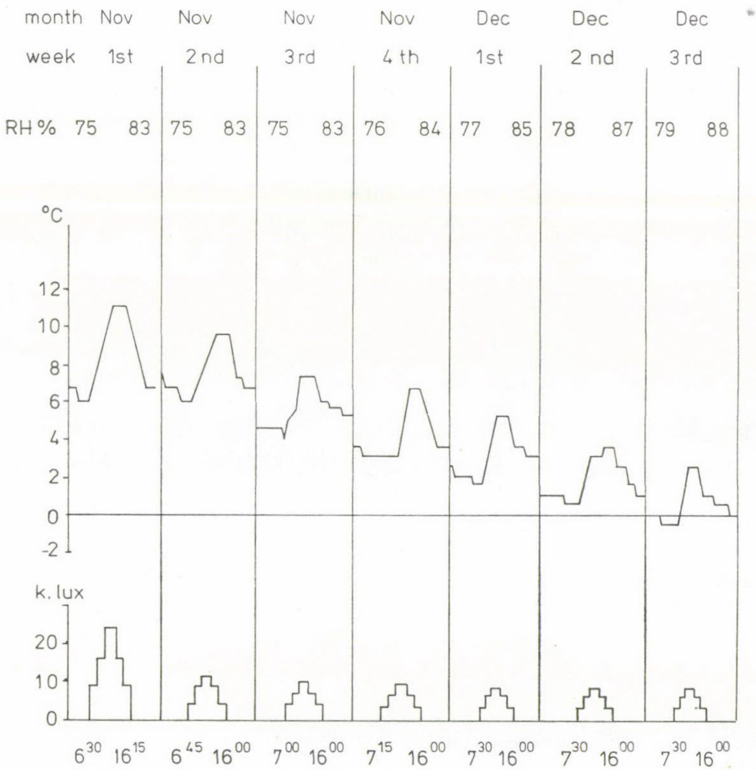


Fig. 6. **N climatic programme with the daily rhythm of weekly changing temperatures and light intensities**

Of the boxes kept in the open, three sets of four boxes (variant 1.2) were brought into the phytotron for freezing at the beginning of each of the months December (D), January (J), February (F) and March (M), while the remainder were left to overwinter in the open (variant 1.4). As required in the programme, one set of four boxes from each of the three raising programmes was taken out of the phytotron, so that the plants could overwinter in the open (variant 1.3).

Freezing was carried out at —6, —12 and —18 °C after the second phase of hardening. First, the temperature in the C unit was programmed at —6°C and three sets of boxes from each phytotron raising programme (variant 1.1) received frost treatment at this temperature for 24 hours. The frost treatment was continued on two sets from each programme at —12 °C for a further 24 hours, and finally on one set from each programme at —18°C, again for 24 hours. The same procedure was carried out with the three sets of boxes brought into the phytotron each month from outside for freezing (variant 1.2). The changes in temperature during both freezing and thawing were made gradually.

For thawing the boxes were kept at 0—+0.5 °C for 2 days, then the plants were pinched back to 1—1.5 cm above the soil and were put in a GB unit for recovery and regrowth. In this unit a temperature of 15—16 °C and a light intensity of 10,000 lux were programmed for 4 weeks.

After this the number of surviving plants was determined. This was also done for the plants which were grown and overwintered in the open (variant 1.4) and for those which were raised in the phytotron and then put into the open for overwintering (variant 1.3). At the same time the developmental state of the growing tip was again determined and the length of the main shoot was measured.

The % survival data obtained in Experiment 1 for the various raising programmes are summarised in Table 1, from which the following conclusions can be drawn:

Table 1

% survival as a function of the method of raising, after freezing at —18 °C or overwintering in the open

Raising		% survival			
		frozen at —18°C		overwintered in the open	
		Mir 808	Bez 1	Mir 808	Bez 1
Climatic programme	S	2.7	0.0	75.6	64.1
	O	14.9	21.9	89.3	82.2
	N	68.9	71.6	97.2	93.6
$LSD_{(0.05)}$		21.2		12.7	
Brought in to the phytotron	D	32.3	49.1		
	J	60.2	56.6		
	F	22.5	28.4		
	M	0.0	0.0		
$LSD_{(0.05)}$		23.9			
Kept in the open				97.4	96.2
$LSD_{(0.05)}$				8.1	

a) For plants raised in the phytotron on various climatic programmes and overwintered in the open the highest % survival values for the two varieties presented was registered in the N raising programme. These values did not differ from those recorded for plants raised and overwintered in the open, which demonstrates the efficiency of the phytotron raising programme.

b) The % survival of plants frozen in the phytotron at —18 °C varied considerably, depending on the raising conditions. Of those grown in the phytotron those from the N programme again gave the highest % survival values, but these were considerably lower than the % survival values of plants from the same raising programme overwintered in the open. This shows that —18 °C freezing in the phytotron exposed the plants to much more severe stress than was experienced in the open in the year in question.

c) The % survival of plants brought into the phytotron at various times for freezing at —18 °C varied considerably depending on the time at which they were brought in. The highest % survival values were registered for those frozen after being brought in at the beginning of January. These values were similar to those obtained for plants raised in the best (N) phytotron programme and frozen at —18 °C. The % survival for plants brought in for freezing at the beginning of December was considerably lower, followed by those kept in the open until the beginning of February. Those kept in the open until the beginning of March were destroyed completely by freezing at —18 °C, which proves that in the year in question the plants had practically lost their hardiness by the beginning of March.

d) In plants which are just tillering the developmental stage of the growing tip and the length of the main shoot at both measuring times, i.e. before freezing and four weeks after freezing, was identical both in plants brought in from the field in January and in those raised in the phytotron on the N raising programme, and in these two treatments the growth and development of the plants after freezing was optimum, i.e. it was more favourable than in any other treatment.

e) The trend of % survival values was identical in the two varieties presented.

The frost resistance values of winter wheat plants determined in this experiment by freezing them in successive winter months confirm the data reported by Dorofeev *et al.* (1973), Vinogradova (1976) and Koch (1977), which indicate that the frost resistance of plants is most pronounced in the middle of the winter. From then onwards, however, once the vernalisation period has finished (Rajki 1960), the protection against frost damage acquired by hardening in late autumn and early winter gradually decreases and by the end of winter or early spring it has practically disappeared.

I have found no reference in the literature to any other studies on the frost resistance of plants raised in phytotron programmes simulating different types of autumn climatic conditions.

Experiment 2

The aim of this experiment was to perfect the climatic programmes used for pre-hardening growth and to shorten the testing time as much as possible. The experiment was set up as per variant 1.1 of Experiment 1 (i.e. plants grown and frozen in the phytotron), with the only difference that besides the N programme which proved optimum in Experiment 1, a climatic programme (O_3) simulating conditions beginning in the 3rd week of October (the optimum sowing time for winter wheat in Hungary) was used for raising the plants. The programmes were carried out for either 6 weeks or 4 weeks (Fig. 7). The experimental data, which are in agreement with the results of several similar experiments, can be seen in Table 2, from which the following conclusions can be drawn:

a) The % survival values of plants raised for 6 weeks on climatic programme O_3 (i.e. until they had tillered), then hardened, and frozen at —18 °C were better than those for plants

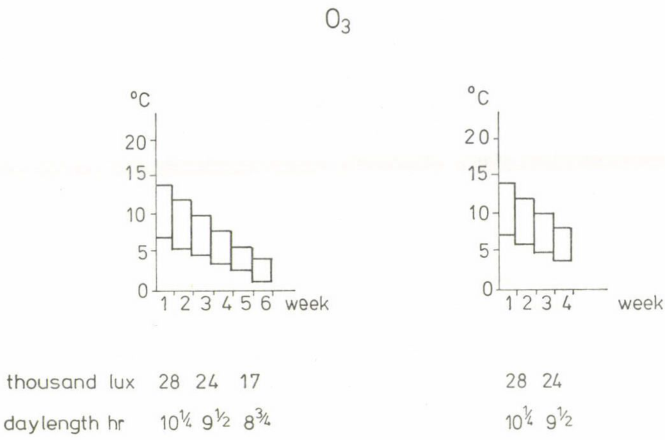


Fig. 7. **Temperature, light intensity and daylength for various programmes in the phytotron**

Table 2

% survival as a function of the method and duration of raising, after freezing at —18 °C

Raising			No. of leaves before freezing	% survival	
method		duration weeks		Mir 808	Bez 1
Climatic programme	N (M15)	6	3	92.1	68.0
		4	2	55.3	23.0
	O_3 (M29)	6	4—5	92.0	86.8
		4	3	74.7	68.4

Means of		N	O_3
	(2)	6 weeks	4 weeks
	(3)	Mir 808	Bez 1
Programmes (1)		60.5	79.9
Duration (2)		84.7	55.7
Varieties (3)		78.3	62.1

$LSD_{(0.05)} = 11.1$

raised for 7 weeks on the N programme which proved optimum in Experiment 1, then hardened, and frozen at —18 °C.

b) **Compared to the 6 week raising period, raising for only 4 weeks resulted in a significant reduction in the % survival.**

c) Consequently, when using the optimum O_3 climatic programme, the raising period prior to hardening and freezing could be reduced from 7 to 6 weeks.

The results of these experiments are basically the same as those reported by TRUNOVA (1967), who reported that the hardening of winter wheat plants was less effective at the 2—3 leaf stage than at the tillering stage, and by FREYMAN (1978), who found that after suitable hardening the frost resistance of 4 week old plants was better than that of 2-week-old plants.

Experiment 3

In many cases the importance of raising prior to hardening and freezing in the correct testing of frost resistance is under-estimated, which means that over-simplified climatic programmes (e.g. constant day and night temperatures or even programmes "simulating" spring climatic conditions) are often used. The following experiment, which included three raising methods and four treatments for the first phase of hardening, was designed to investigate this.

In addition to the O_3 climatic programme, which has been used for raising in our frost resistance tests for a number of years, a simulated spring climatic programme was set up, in which the temperature and light intensity changed according to a daily rhythm and increased each week, together with the daylength. The extreme values of day/night temperatures in the first week were 12.5 and 5.5 °C and in the sixth week 21.0 and 11.5 °C, while the daylength increased from 13 1/4 to 15 1/4 hours and the light intensity from 35,000 to 37,000 lux. The third raising programme can be called intermediate, as it consisted throughout the six weeks of day/night temperatures of 15 °/7 °C, a daylength of 12 hours and a light intensity of 25,000 lux.

The parameters of the treatments for the first phase of hardening are summarised below.

Climatic factors	Hardening programmes			
	H_1	H_2	H_3	H_4
Temperature	from +3°C to −3°C		2°C	
Daylength, hours	21	8	8	21
Light intensity, lux	15,000			

The following important conclusions can be drawn from Table 3, which summarises the results of Experiment 3.

a) As expected, in the development of frost resistance the O_3 raising programme and the H_1 hardening treatment, i.e. here too that which is normally used, proved optimum.

b) Under less favourable technical conditions, where it is not possible to programme sub-zero temperatures combined with high light intensity, the H_4 hardening programme may prove useful.

It is interesting to note that the growing tips of plants from the varieties included in Table 3 were at stages 1—2 (on the Kuperman scale) at the end of all three raising programmes, but compared to the plants raised on the O_3 climatic programme, the length of the growing tip was three times as long in the intermediate programme and four times as long in the spring programme, though they were still far shorter than those of the spring wheats examined in the experiment.

Table 3

% survival as a function of the method of raising and the first phase of hardening, after freezing at —15 °C

Climatic programme for raising	Climatic programme for hardening							
	H_1		H_2		H_3		H_4	
	Mir 808	Bez 1	Mir 808	Bez 1	Mir 808	Bez 1	Mir 808	Bez 1
O_3	97.4	90.8	98.7	80.5	86.1	39.1	83.5	80.0
Intermediate	86.2	67.6	17.6	5.0	5.3	1.3	67.0	27.8
Spring	48.0	4.1	14.1	3.8	2.5	0	47.5	2.5

Means of						$LSD_{(0.05)}$
	(1)	H_1	H_2	H_3	H_4	
	(2)	O_3	Int.	Spring		
	(3)	Mir 808	Bez 1			
Hardenings	(1)	65.6	36.5	22.3	51.1	9.4
Programmes	(2)	81.9	34.7	15.0		8.2
Varieties	(3)	54.3	33.5			6.7

Experiment 4

The aim of this experiment was to determine whether the omission of the second phase of hardening reduced the development of frost resistance, and if so, to what extent. The plants were actually frozen at four temperatures (—6, —12, —15 and —18 °C) but only the % survival values obtained after freezing at —18 °C are presented in Table 4. The following conclusions can be drawn from the experiment:

a) Frost resistant varieties (Mironovskaya 808, Bezostaya 1) responded positively to the second phase of hardening.

Table 4

% survival as a function of the second phase of hardening, after raising on climatic programme O_3 and freezing at —18 °C

Varieties	% survival	
	usual hardening	hardening without the second phase
Mir 808	92.5	76.3
Bez 1	91.3	66.3
Etoile de Choisy	3.8	0.0

$LSD_{(0.05)} = 9.6$

b) When freezing was carried out at temperatures above —15 °C there was no significant difference in % survival between those which were exposed to the second phase of hardening and those which were not.

In discussing Experiments 3 and 4 it should be observed that the adequate climatic programmes used by various authors (POMEROY *et al.* 1975, GUSTA—FOWLER 1976, 1977, FREYMAN 1978, etc.) for testing the frost resistance of winter wheat plants raised and hardened in the phytotron are very varied, so it is almost impossible, quite apart from the differences in the varieties examined, to compare their results with those obtained in the present experiments. The latter indicate, however, that the quality of the raising and hardening is of fundamental importance in the development of frost resistance, and that the phytotronic simulation of autumn and early winter climatic conditions proved to have the most favourable effect on the development of frost resistance.

Experiment 5

When freezing winter and spring wheat varieties at various temperatures after raising and hardening under the conditions optimum in the phytotron, the % survival values presented in Table 5 were obtained. These lead to the following conclusions.

a) When freezing at —6 °C there was practically no difference between frost resistant and frost sensitive varieties.

b) A temperature of —18 °C was only withstood with minimum loss by the most frost resistant winter wheat variety, Mironovskaya 808, while all the plants of Sava winter wheat, which is slightly frost resistant under Hungarian conditions, were destroyed, as were those of the spring wheat Siete Cerros.

c) Freezing at —15 °C proved optimum for differentiating the varieties found in Hungary with respect to frost resistance, as at this temperature the spring wheats were completely destroyed, while a small percentage of plants from slightly frost resistant winter wheat varieties survived freezing, so the scale of frost resistance was the most accurate in this case.

Table 5

% survival as a function of freezing temperature, after raising on climatic programme O_3

Variety	% survival after freezing at			
	—6	—12	—15	—18
	°C			
Mir 808	100.0	92.5	94.9	92.5
Bánkúti 1201	92.3	70.3	47.5	28.8
Etoile de Choisy	97.4	59.0	12.7	3.8
Sava	93.7	63.7	17.5	0.0
Siete Cerros	93.8	0.0	0.0	0.0

$LSD_{(0.05)} = 8.8$

Experiment 6

A comparison was made of the % survival values of plants kept in the open during the autumn and for part of the winter, then brought into the phytotron for freezing once a month from the beginning of December to the beginning of March in 1972/73 and 1977/78.

In both years the % survival values after freezing at —18 °C are presented, as freezing was not carried out at —15°C in 1972/73. Certain meteorological parameters for the two years are demonstrated in Figs 8 and 9. The % survival values are summarised according to years and varieties in Table 6, from which the following conclusions can be drawn:

a) In each treatment and each variety the % survival values in 1977/78 are consistently higher than in 1972/73, which can be explained by the fact that the autumn meteorological conditions differed to a certain extent in the two years, i.e. by the fact that the growth and development of the plants, in particular the hardening, took place under these differing conditions.

Table 6

% survival as a function of the year; plants grown outside and frozen in the phytotron at —18 °C

Plants grown outside till		Mir 808		Bez 1		Etoile de Choisy		Libellula	
		72/73	77/78	72/73	77/78	72/73	77/78	72/73	77/78
December	(D)	32.4	59.5	49.4	41.8	0.0	0.0	0.0	0.0
January	(J)	60.0	92.4	56.4	78.5	10.0	18.4	0.0	2.5
February	(F)	23.2	88.0	28.5	70.5	3.9	12.8	2.5	14.1
March	(M)	0.0	8.9	0.0	2.5	0.0	1.3	0.0	0.0

$LSD_{(0.05)} = 14.8$

b) The loss of hardiness progressed at a slower rate in 1977/78 than in 1972/73, as can be seen by a comparison of the % survival values in the February and March freezings. Whereas in the March of 1972/73 all the plants of all four varieties were destroyed by freezing, in the March of 1977/78 a small percentage of plants survived freezing in three of the four varieties. In 1977/78 the reduction in the % survival in February compared to the January values was also less than in 1972/73.

Data on the frost resistance of the same varieties in different years were published by BARASHKOVA *et al.* (1976). The values of frost resistance for the different years vary, but the order of magnitude for the varieties is in agreement with the results given here.

Experiment 7

The phenomenon of rehardening at the end of winter was most apparent in the March of 1972/73. This is illustrated by Table 7, from which it can be seen that:

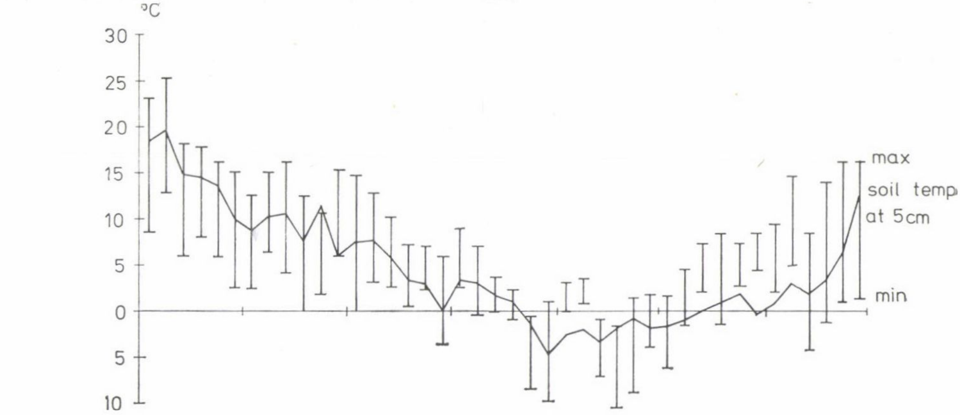
Table 7

% survival of plants grown outside and frozen in the phytotron at —6 °C. 1972/73

Variety	Plants grown outside till early			
	December	January	February	March
Mir 808	86.3	91.8	82.7	94.7
Bez 1	90.0	88.5	65.8	84.7
Etoile de Choisy	91.0	59.0	47.5	82.7

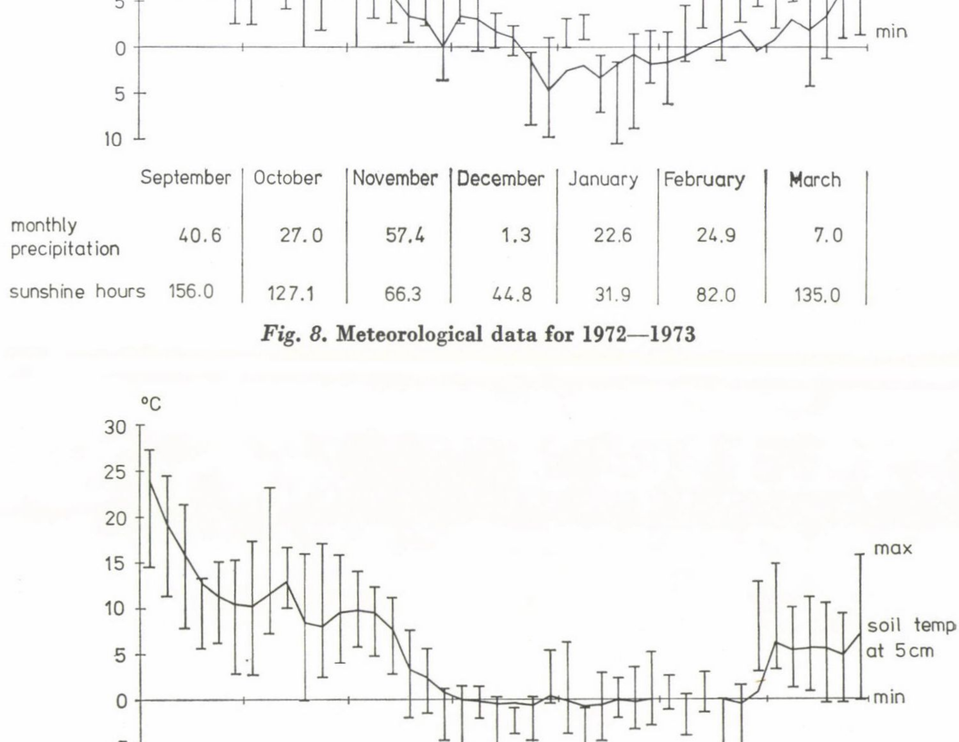
$LSD_{(0.05)} = 15.8$

a) in all three winter wheat varieties presented, the % survival values in February were much lower than in January (dehardening), but in March a considerable improvement was found compared to February and in two of the three varieties, including the slightly to medium frost resistant Etoile de Choisy, this increase was significant (rehardening).



	September	October	November	December	January	February	March
monthly precipitation	40.6	27.0	57.4	1.3	22.6	24.9	7.0
sunshine hours	156.0	127.1	66.3	44.8	31.9	82.0	135.0

***Fig. 8.* Meteorological data for 1972—1973**



	September	October	November	December	January	February	March
monthly precipitation	28.0	12.7	57.4	15.6	18.9	38.9	20.5
sunshine hours	168.1	134.5	69.9	17.9	41.6	46.6	140.1

***Fig. 9.* Meteorological data for 1977—1978**

b) rehardening may be important in reducing the plant destruction caused by recurring frosts at the end of winter or in early spring.

The phenomenon of rehardening has been described by several authors (ANDREWS *et al.* 1974, FOWLER—GUSTA 1977, GUSTA—FOWLER 1976, etc.). The results presented by Andrews and co-workers, for example, differ from those of the present experiments in that the Canadian authors found the greatest degree of rehardening in the most frost resistant wheats, while here the rehardening was most pronounced in the slightly to medium frost resistant variety.

Table 8

% survival during recovery and μS values; plants grown and frozen at —18 °C in the phytotron

Variety	% survival — weeks after freezing: 1	2	3	4	Electrical conductivity, μS
Mir 808	100.0	94.5	91.7	86.3	5.65
Bez 1	95.9	89.3	86.6	85.4	7.87
Kavkaz	98.7	93.3	91.9	86.4	6.10
F 293	93.7	79.7	70.7	68.2	8.67
B 1201	92.1	69.7	61.8	56.6	9.67
Etoile de Choisy	73.3	35.1	24.2	22.9	9.20
Sava	73.4	20.9	18.2	16.9	13.69
Libellula	64.6	22.9	8.9	7.6	13.01
Siete Cerros	19.7	0.0	0.0	0.0	19.30
$LSD_{(0.05)}$ = 16.5					1.87

Table 9

% survival of 10 winter wheat varieties, grown in the climatic programme O_3, frozen at —15 °C

Variety	% survival: 1975	1976	1977	$\bar{x}$
Mir 808	97.4	93.7	80.0	90.4
Yub 50	91.4	92.4	80.0	87.9
Bez 1	80.0	97.4	57.7	78.4
Mv 1	81.2	87.3	83.5	84.0
Mv 4	90.0	95.9	79.8	88.6
Mv 5	77.2	98.7	86.2	87.4
GK 3	68.5	69.7	82.3	73.5
Partizanka	84.8	78.2	68.8	77.3
Sava	33.3	10.4	35.1	26.3
Libellula	30.0	2.6	8.9	13.8

Experiment 8

As can be seen in the description of Experiment 1, recovery and regrowth after freezing originally took four weeks. In order to reduce the length of the frost resistance test, investigations have since been made to discover whether recovery and regrowth and the relevant plant counts can be carried out in less than 4 weeks. In addition, studies were made to determine whether the whole procedure could be replaced by the measurement of electrical conductivity (DEXTER 1956, JENKINS—ROFFEY 1974) directly after thawing. For this purpose, the first leaf of some of the plants was cut off before the leaves were pinched back and the electrical conductivity determined with a Conductivity meter (OK 102/1, Radelkis) was expressed in micro-Siemens (μS). The results of Experiment 8 are summarised in Table 8, from which the following conclusions can be drawn:

a) Data from plant counts carried out in the 2nd and 3rd week of recovery and regrowth show that the number of plants which had survived freezing hardly decreased in the third week as compared to the second, so the recovery and regrowth period in the frost resistance tests was reduced to three weeks.

b) It could be seen from the measurements of electrical conductivity that the method is only suitable for differentiating varieties with widely different frost resistance, for the preliminary evaluation of frost resistance, or for sifting out varieties with weak frost resistance.

JENKINS—ROFFEY (1974) give a similar opinion of the utility of electrical conductivity measurements.

Experiment 9

The % survival values for a collection of winter wheats which are important in Hungary, measured using the method developed at Martonvásár and already used for a number of years to test the frost resistance of wheat varieties, experimental hybrids and lines, are summarised in Table 9, from which the following conclusions can be drawn.

a) The frost resistance of the majority of the winter wheat varieties examined was good or excellent, and there was less variation over the years in the frost resistance of these varieties than in that of only slightly frost resistant varieties.

b) The varieties Sava and Libellula, shown by the frost resistance test to be only slightly frost resistant, together with other slightly frost resistant winter wheat varieties, are among those which, during the winter of 1978/79 (a winter described by the meteorologists as less severe than average, but nevertheless harder than the Mediterranean winters experienced in Hungary over the last decade), were destroyed so completely over considerable areas that the farms were obliged to plough them out and replant the fields with spring crops. These varieties were also responsible for the significant areas where the destruction was less drastic and where the farms endeavoured to save the crop by overplanting with spring cereals.

Experiment 10

An attempt was made to reproduce in the phytotron the effect of a temporary thaw towards the end of winter, followed by another frost, on young plants of wheat varieties with different degrees of frost resistance.

The plants were raised on climatic programme O_3 for six weeks, after which they were subjected to the usual hardening and to freezing at —15 °C. Following this, the control plants were thawed out and the frost resistance was determined on the basis of regrowth values.

The remaining, experimental plants were divided into two groups, which were exposed to different "temporary late-winter thaw" programmes. For the first group this consisted of the temperatures used in the first phase of hardening, i.e. 3 °C during the day and —3 °C

Table 10

% survival as a function of the second freezing following temporary late-winter thaw reproduced in the phytotron; raising: on climatic programme O_3, first freezing at —15 °C, second freezing at —7.5 °C

Varieties	% survival		
	after freezing at —15 °C		
	plus thawing out and regrowth: control	plus thawing corresponding to the 1st phase of the usual hardening	plus special thawing
		followed by second freezing at —7.5 °C, etc.	
Mir 808	92.3	86.3	81.3
Bez 1	88.8	76.3	49.0
Etoile de Choisy	43.8	15.0	3.8
Sava	21.9	7.5	5.0
Libellula	5.0	3.8	1.3

$LSD_{(0.05)} = 17.6$

at night for a week, with 21 hour illumination and 15,000 lux light intensity. For the second group a day temperature of 7 °C and a night temperature of 2 °C was programmed, with 10 hours of illumination at a light intensity of 15,000 lux.

For both groups of experimental plants refreezing was carried out at —7.5 °C, beginning with the second stage of hardening, as in all the freezing treatments. Here, too, this was followed by thawing out and the determination of frost resistance on the basis of regrowth values.

The experimental results (Table 10) show that wheat varieties with various degrees of frost resistance respond differently to a second freezing after the temporary late-winter thaw reproduced in the phytotron.

a) The most frost resistant variety examined, Mironovskaya 808, showed no response to a second freezing following the late-winter thaw.

b) When frozen after a thaw corresponding to a repetition of the first phase of hardening, Bezostaya 1 maintained its excellent frost resistance, but freezing after the special thawing programme considerably reduced the frost resistance. Thus, the first phase of the second hardening represented rehardening, while the special thaw caused dehardening.

c) The frost resistance of Etoile de Choisy, which has weak to medium frost resistance, and in particular that of Sava and Libellula, which have poor frost resistance, was reduced to a minimum by both thawing treatments.

Final discussion and conclusions

It is sufficient to cast a glance at Fig. 10, which shows the mean winter temperatures for the last 198 years, to observe that the mean winter temperature for the first 9 years of the seventies was the warmest yet in Hungary, compared to all the rest of the decade averages. This means that if the determination of the frost resistance of the winter wheat breeding stock had been left to selection by natural exposure in the field the nurseries would be full of lines, experimental hybrids and varieties with poor frost resistance. The widespread use of slightly

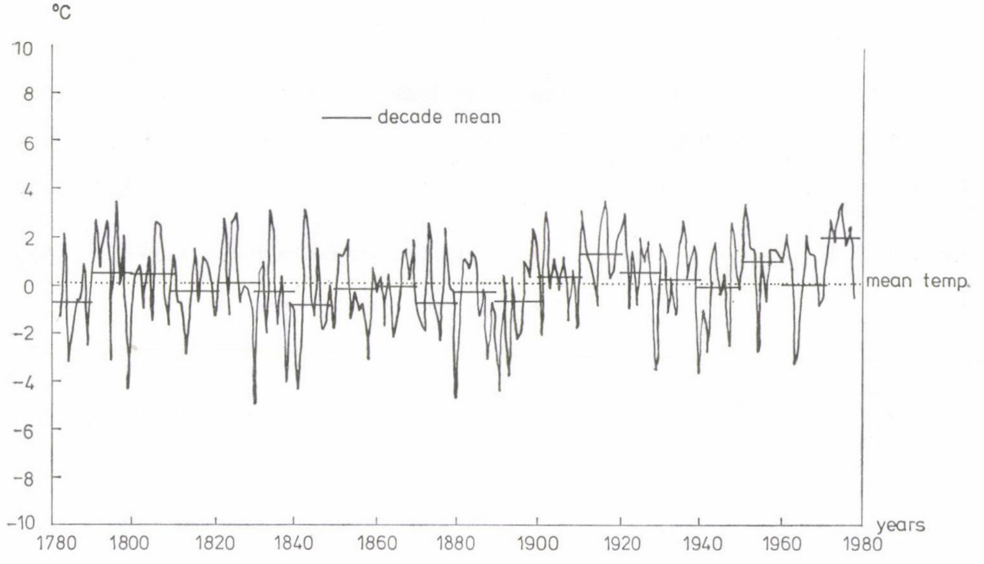


Fig. 10. Winter (Dec. Jan. Feb.) mean temperatures (1781—1979)

frost resistant sources of dwarfness in the production of modern wheat types which are resistant to lodging and which assimilate economically, i.e. with favourable harvest indices, has also led to the accumulation of breeding material with weak frost resistance.

Consequently, the significance, primarily from a breeding point of view, of the development of a phytotron method for testing frost resistance and the continual use of this method at Martonvásár over the last 7 years is virtually immeasurable.

The climatic programmes for the preparation and raising of plants for freezing simulate nature as near to perfectly as is possible with the technical facilities available in the phytotron. Without these climatic programmes, which provide an environment favourable for the growth and development of the plant, it would be virtually impossible to test breeding stock for frost resistance reliably, consistently and independently of the external weather conditions.

Acknowledgements

Thanks are due to Sándor Rajki for his continual help and advice throughout the experimentation and in the preparation of the manuscript. I am also grateful for the cooperation of László Balla, head of the wheat breeding team, whose observations over the years, during the testing of the breeding stock, proved very useful in elaborating the test. Without the help, advice and cooperation of these colleagues, and the accurate, conscientious work of the biostatisticians and the technical staff responsible for plant raising and testing, this paper could not have been written.

E. Rajki
Agricultural Research Institute
of the Hungarian Academy of Sciences,
Martonvásár

References

Åkerman, A.—Lindberg, J. (1927): Studien über Kältetod und die Kälteresistenz der Pflanzen. Veröffentl. d. Knut und Alice Wallenberg-Stiftung, 10.

Andrews, C. J.—Pomeroy, M. K.—De La Roche, I. A. (1974): Changes in cold hardiness of overwintering winter wheat. Can. J. Plant Sci., **54**, 9—15.

Barashkova, E. A.—Alekseeva, E. N.—Vinogradova, V. V.—Барашкова Э. А.—Алексеева Е. Н.—Виноградова В. В. (1976): Морозоустойчивость некоторых сортов озимой пшеницы из разных стран. Бюлл. ВИРа, **63**, 44—48.

Dexter, S. T. (1956): The evaluation of crop plants for winter hardiness. Advances in Agronomy, **8**, 203—239.

Dorofeev, V. F.—Novikova, M. V.—Gradchaninova, O. D.—Barashkova, E. A.—Vinogradova, V. V.—Дорофеев В. Ф.—Новикова М. В.—Градчанинова О. Д.—Барашкова Э. А.—Виноградова В. В. ;(1973): Методы оценки образцов коллекции озимой пшеницы на морозостойкость. Зимостойкие пшеницы, ВИР, Ленинград, 117—145.

Fowler, D. B.—Gusta, L. V. (1977): Dehardening of winter wheat and rye under spring field conditions. Can. J. Plant Sci., **57**, 1049—1054.

Freyman, S. (1978): Influence of duration of growth, seed size and seeding depth on cold hardiness of two hardy winter wheat cultivars. Can. J. Plant Sci., **58**, 917—921.

Gusta, L. V.—Fowler, D. B. (1976): Effects of temperature on dehardening and rehardening of winter cereals. Can. J. Plant Sci., **56**, 673—678.

Gusta, L. V.—Fowler, D. B. (1977): Factors affecting the cold survival of winter cereals. Can. J. Plant Sci., **57**, 213—219.

Jenkins, G.—Roffey, A. P. (1974): A method of estimating the cold hardiness of cereals by measuring electrical conductance after freezing. J. Agr. Sci. (Camb.), **83**, 87—92.

Koch, H. D. (1977): Frost resistance reaction of different barley and wheat varieties after varied duration of plant vernalization under artificial climate conditions. Arch. Züchtungsforsch., **7**, 29—42.

Pletser, J. (1973): Climatic model for phytotron studies. Acta Agron. Hung., **22**, 67—80.

Pomeroy, M. K.—Andrews, C. J.—Fedak, G. (1975): Cold hardening and dehardening responses in winter wheat and winter barley. Can. J. Plant Sci., **55**, 529—535.

Rajki, S. (1960): Közönséges búzafajták tenyészideje és megváltoztatásának egyes módjai (Vegetation period of some common wheat varieties and certain ways of changing them). Növénytermelés, **9**, 113—130.

Rajki, S. (1973): Research strategy of the Martonvásár Phytotron. Phytotronic Newsletters 4, 5, 6, 42—46.

Trunova, T. I.—Трунова Т. И. (1967): Методы определения морозосойкости озимых растений. Методы определения морозосойкости растений. Наука, Москва, 51—76.

Tumanov, L. I.—Туманов И. И. (1935): Ускоренные методы оценки зимостойкости растений. Теоретические основы селекции. Москва—Ленинград, Гос. изд. с/х совх. и колх. лит., **1**, 753—782.

Vinogradova, V. V.—Виноградова В. В. (1976): Динамика мороровоустойчивости озимой пшеницы и выбор срока сравнительной оценки сортов по этому признаку. Методы оценки устойчивости растений к неблагоприятным условиям среды. Колос, Ленинград, 132—137.

RECENSIONES

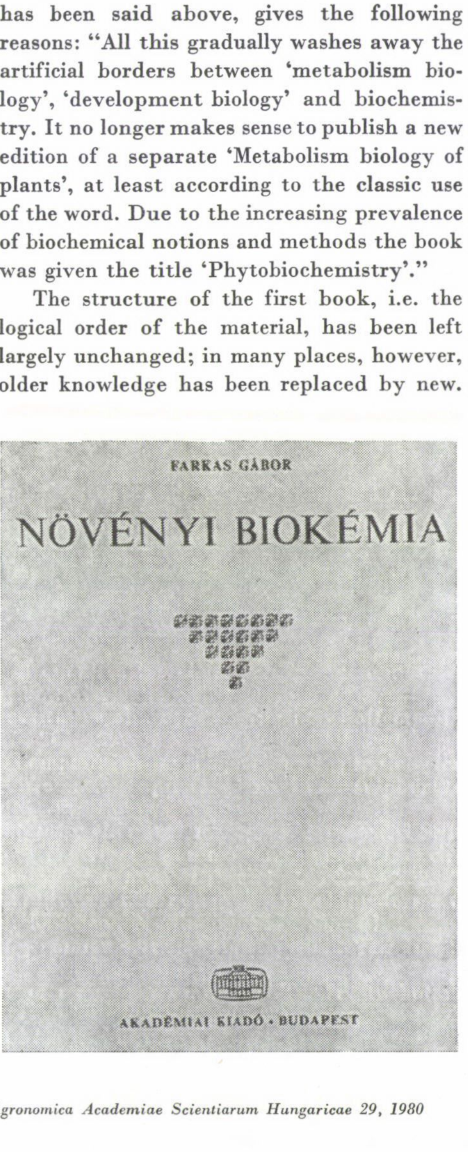
G. Farkas: *Növényi biokémia* (Phytobiochemistry). Akadémiai Kiadó, Budapest, 1978, 404.

Among this year's scientific publications on the Hungarian book market one of the most sought after and most successful works was Farkas's Phytobiochemistry. It sold out so quickly after publication that it is now on the request list in the book shops.

The author needs no introduction: he is the director of the Plant Physiology Institute of the Szeged Biological Centre of the Hungarian Academy of Sciences, a researcher well known both at home and abroad for several decades through his work and results in the field of the metabolism biology of plants. "Phytobiochemistry" is a revised edition of the author's work "Növényi anyagcsereélettan" (Metabolism biology of plants), which was published in 1968. This first book, an excellent source of information, has been worn out from much use over the last ten years. In addition, certain parts of the book have in the meantime become outdated. As the author writes in the preface, "Ten years have elapsed since the publication of the 'Metabolism biology of plants'. At the rate at which biology is developing at present this is a long time; more than the 'half-life' of a book. A new edition must reflect the progress made both in factual knowledge and in our approach to the subject". In addition to this, more and more use is being made in plant physiology of the most up-to-date biochemical methods, that have rendered it possible to attain the recent results. Thus, the publication of a revised edition of this work was a very pressing need.

The new edition has been given a different title, for which the Author, referring to what has been said above, gives the following reasons: "All this gradually washes away the artificial borders between 'metabolism biology', 'development biology' and biochemistry. It no longer makes sense to publish a new edition of a separate 'Metabolism biology of plants', at least according to the classic use of the word. Due to the increasing prevalence of biochemical notions and methods the book was given the title 'Phytobiochemistry'."

The structure of the first book, i.e. the logical order of the material, has been left largely unchanged; in many places, however, older knowledge has been replaced by new.



Even in the relatively unchanged chapters a certain amount of regrouping and innovation has taken place. The aim of the new work is not only to freshen up the material but also, like the old, to offer the reader a more or less clarified view. It thus neglects the historical angle, and concentrates on summarizing the present knowledge of metabolic phenomena in plants. However, constant reference is made to problems as yet unsolved and to those which are expected to be settled in the near future.

The characteristic features which lent an outstanding value and a unique profile to the earlier book are manifest even more strongly in "Phytobiochemistry".

Although the material of the book cannot be separated from biochemistry in general, it is nevertheless emphatically plant biochemistry. The metabolic processes which are identical and of equal importance in animal, bacterial and vegetable systems are briefly discussed by the Author, who also points out how the functioning of these life processes has been proved in plants. The book is made quite exciting by the comparative view with which the Author discusses the similar and divergent characteristics of animal and vegetable metabolism. In this type of discussion the emphasis is always laid on the plants, and in some chapters certain phenomena specific to plant physiology are dealt with.

Another characteristic feature of the book is that unlike the usual manuals not only are the facts presented, but also their experimental proofs and the way in which the conclusions were reached. In this way the reader becomes acquainted with the up-to-date methodology which forms the basis of plant physiology research today, and since the experimental evidence is given the conclusions can also be more clearly followed. This type of discussion makes the reader virtually a participant in the creative work of research, and necessarily results in a strengthening of the biochemical way of looking at the subject. "I think this way of treating the subject can give something more lasting than a mere knowledge of the material, however necessary that may be", the Author says.

The methodological sections and the minor details of the individual subjects are given in smaller print and are marked with a line in the margin. These parts, though not indispensable for understanding the essentials of the individual metabolic processes, deepen the reader's knowledge and greatly influence his way of thinking.

The biochemistry of the metabolic processes of plants is discussed in nine chapters.

I. Photosynthesis. This chapter is one of those which is most thoroughly revised compared to the material of the first book. In the biochemistry of chlorophylls only minor changes are found, while a description of the electron transport chain has been added to the photosynthesis of bacteria. The following subjects, on the other hand, have been considerably revised: the biosynthesis of chlorophylls, the accessory pigments, the uptake of light energy, and the Calvin-cycle, the C_3-pathway of CO_2 fixation; the rest of the chapter has been almost completely rewritten and presents new data. These sections include the structural aspects of photosynthesis, the transformation of light energy into chemical energy, and the reduction of carbon dioxide. The new results achieved in investigations on the energetic background of photophosphorylation, the C_4-pathway of CO_2 fixation, photorespiration and the photosynthetic ATP formation of Halobacteria justified the insertion of new subchapters.

II. Respiration. The development in our knowledge of the respirative metabolism has been restricted to minor details over the past ten years. Accordingly, the Author has left the original text practically unchanged apart from occasional condensations and minor additions. The treatment of the glyoxalate-cycle has been brought up to date, and the sections on the mitochondrial electron transport chain and its components, and on the mechanism of oxidative phosphorylation have been revised; the discussion of cyanide resistant respiration opens up quite new vistas.

III. Metabolism of lipoids. In recent years the research on lipids has yielded particularly outstanding results. This is duly reflected in

Farkas's book: the chapter is quite different to that in the first book. The sections on lipoids and cell membranes have mostly been rewritten, and the mechanism of β-oxidation in saturated and unsaturated fatty acids, a new type of α-oxidation, and the biosynthesis of lipoids appear in new formulations. Finally, a good comprehensive view is offered of the biosynthetic pathways of vegetal lipids.

IV. Research on Nitrogen and sulphur autotrophy, and in particular on the fixation of atmospheric nitrogen has made great progress lately, due in large part to the practical importance of these subjects. The Author has, accordingly, considerably revised the material of symbiotic and asymbiotic nitrogen fixation. A completely new formulation was required to describe the mechanism of sulphate reduction and the biochemistry of nitrogen fixation.

V. The chapter on the Metabolism of amino acids has not changed much, due to the lack of new results of major importance. New data are found mostly in the section dealing with the biosynthesis of amino acids, particularly with regard to the serine, asparagine and glutamine families. In connection with the metabolism of carbamide, the modification of the carbamide cycle in accordance with the characteristics of plants contributes to the emphasis on plant specificities.

VI. Much the same can be said about the chapter on the Metabolism of nucleotides as was said of the former chapter. Adjustments, abridgements and revisions have taken place in both subchapters, particularly in connection with the biosynthesis of purine and pyrimidine and with the decomposition of mononucleotides.

VII. Nucleic acid metabolism. As in the case of a number of other chapters, the explosive development of our knowledge on nucleic acids made a totally new formulation necessary in this chapter.

It also had to be taken into consideration that, despite a certain time-lag, the results of investigations on the nucleic acids of plants are gradually reaching the level attained with microbial materials and animal tissues. It is due to this fact that the material presented in the book on this subject is mostly new and is of a much more "vegetal character" than it was before. It is also noticeable that in this new edition much more data on eukaryotes is to be found. The chapter contains interesting new information concerning the structures of various types of DNA and RNA, their occurrence, synthesis and decomposition. The treatment of ribosomes has undergone less alteration.

VIII. Protein metabolism. The rapid rate of progress in the research on proteins, including vegetable proteins, is shown by the material of this revised chapter. Many parts have been greatly modernized compared to the former book, and the subchapters on the biochemical mechanism of protein synthesis, the control of protein synthesis, and the decomposition of proteins have been completely rewritten. Exciting problems of plant development are touched upon in the last section, which, when discussing certain special aspects of nucleic acid and protein metabolism in higher plants, steps at times beyond the limits of the chapter.

IX. Secondary metabolic products. This chapter deals with the biosynthesis of aromatic compounds and alkaloids very concisely, and supplies disproportionately little information compared to the former chapters. Considering the intensive research and practical importance of these products a somewhat more detailed discussion would be desirable.

The discussion of vegetable metabolism is hardly complete without a description of the biochemistry of mineral nutrition. Since the uptake and incorporation of nutrients are of fundamental importance in the life of the plant and are the preconditions for other metabolic processes, the biochemical side of these problems ought to have been summarized in a separate chapter, particularly as enormous progress has also been made in research connected with ion uptake.

The book sums up the achievements of basic research, as it aims to do. However, basic research in plant physiology at present and in the near future has important practical objectives too. The absence of references to these is a deficiency of the book, as they would definitely increase the interest and widen the horizon of the reader.

The structure of the book, the construction of the chapters and the sequence of ideas in them are extremely logical. The clear, concise and stylistically pure mode of expression deserves special mention. The absence of unnecessary foreign words in the text is welcome, since their use in Hungarian scientific language is reaching worrying proportions.

As regards its contents, style of discussion and size Farkas's book satisfies various demands. It is an excellent manual for plant physiologists, a useful guide for the extension training of biology teachers, and will be very useful as a text-book in higher education, particularly as there are no university text-books or lecture notes available on this subject.

At the rate at which biology is developing at present books on this subject are increasingly exposed to the danger of quickly becoming out-dated. Therefore, in order to speed up publication the book was prepared from a typewritten text using a photographic technique. This has the advantage of considerably shortening the time required for publication, and results in a well-arranged, easy-to-read format. It is a pity that photographs cannot be published with this technique, but even so the illustrations of the book are very good. The 183 figures, which are mostly new, present chemical reactions, diagrams and didactically constructed models of the course of various metabolic processes and of their correlations. The figures are much clearer and more expressive than in the former work, and they and the 32 tables are of great assistance in understanding and memorising the material.

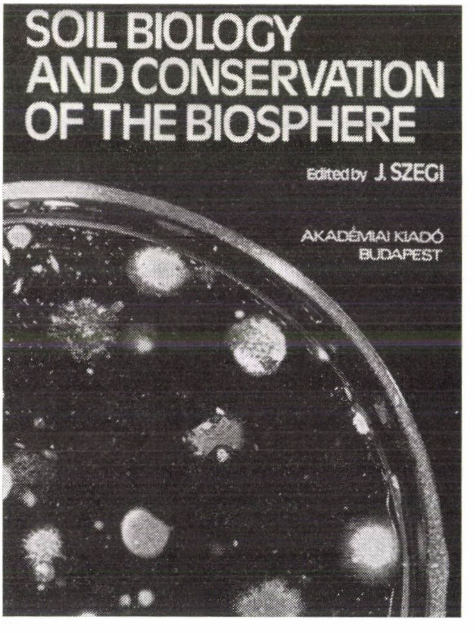
The revision of the contents and the desire to propagate the most up-to-date knowledge and ideas on the subject are also clear from the literary references. The revision was made using the material of fifty books and manuals on plant physiology, biochemistry and genetics published between 1975 and 1977 in English and Russian.

The publication of the long-awaited "Phytobiochemistry" is very welcome. It is a book that excites the interest, holds the attention and encourages further study and work.

M. VARGA

Soil Biology and Conservation of the Biosphere. Akadémiai Kiadó, Budapest, 1977

The title of the book published under the editorship of J. Szegi is the same as that of the VIIth Scientific Session on Soil Biology held by the Soil Biology Section of the Society of Soil Science at the University of Agricultural Sciences, Keszthely, on 2—4th September 1975. The book (424 pages with 29 photos, 147 figures and 137 tables) presents the texts of the lectures delivered at the meeting by 21 Hungarian and 31 foreign experts from 13 countries (Bulgaria, Canada, Chile, Cuba, Czechoslovakia, Egypt, France, German Democratic Republic, German Federal Republic, Poland, Romania, Soviet Union, Spain) in a clear and attractive arrangement.



The lectures delivered in the three sections of the Scientific Session are treated in six chapters. The present review cannot hope to give full particulars of a book which contains mostly new statements made by a number of experts on the basis of their investigations. But it can definitely be said that the book will be an extremely great help to those engaged in research on soil biology, since it contains useful information concerning the role of microorganisms in the soil. The subject of the Scientific Session, and thus that of the book, deserves attention not only from the point of view of soil biology, but also from that of environmental protection.

The first chapter of the book gives the texts of lectures dealing with the interaction between the chemicals used in agriculture and the microorganisms of the soil. The 13 publications by 30 authors to be found in this chapter contain several statements which throw a new light upon the relation of chemicals and microorganisms. As regards the conservation of the biosphere, it is a thought-provoking observation that the genetic structure of *Rhizobium* populations studied over 50 generations in a model experiment changed and the number of mutants increased as a response to pesticide application. Very interesting are the results of experiments concerning the microbial decomposition of various herbicides in the soil. According to the investigations species belonging to the genera *Fusarium* and *Penicillium* take part in the decomposition of alachlorine, alidochlorine and propachlorine.

The rate of decomposition of fungicides varies with the soil type, and also differs in natural and artificial ecosystems. A completely new aspect of the relation between herbicides and soil microorganisms was elucidated by experiments in which the interaction was studied when different rates of fertilization were applied; the inhibition of the microorganisms by the herbicides was found to decrease under such conditions.

Particular attention should be paid to certain research results published in the book which are of importance for practical farmers from the point of view of pesticide utilization. For example, diazinon was found to be applicable without any danger of accumulation, while Hungazin PK or its decomposition product remain active in the soil for a long time and may thus cause problems for environmental protection. Herbicides containing nitraline or trifluraline as active agent were found to have a temporary toxic effect on bacteria, particularly on Rhizobia. According to the investigations the pesticides inhibit the growth of Rhizobium leguminosarum in the order insecticide—fungicide—herbicide. Experiments aimed at examining the possibilities of a combined application of various fungicides and the Rhizobium inoculation used in soybean are also of great importance. The results of the examinations show that Quinolate V-4x strongly inhibits the growth of *Rhizobium japonicum* and the formation of root nodules, but does not cause yield reduction, while Orthocid 50 WP has a different, almost opposite effect. Rhizobium species isolated from the root nodules of various papilionaceous plants (bean, lentil) show nearly equal sensitivity to certain insecticides (e.g. Dipterex), while they are sensitive to fungicides to different degrees.

The second chapter of the book contains the texts of 9 lectures by 14 authors under the title: the role of soil microorganisms in the transformation of plant nutrients. In the fourth chapter 14 lectures by a further 22 authors are to be found with the title: the role of soil microorganisms in the decomposition of plant residues. Not only the similarity between the titles of the two chapters but also that of their contents would have made it reasonable to combine them. This remark does not reduce the value of the publications, the author's merit or the importance and usefulness of the book, but it would have made the book still easier to survey if these chapters, which in my opinion are closely related, had been arranged in immediate succession.

The publications in these two chapters give a good demonstration of the rapid progress made in the field of research on the microbiology of the soil. The papers clearly represent the transformation of research results into a productive force, and the fact that microbiological studies also help to increase production. Most of the publications presented here contain results important not only from a theoretical but also from a practical point of view. Parallel with an increase in the activity of microorganisms and the intensity of microbiological processes the researchers observed considerable changes in production results as well. This favourable effect may be related with the capacity of the microflora living in the rhizosphere to produce growth substances. According to one of the publications in the chapter 87% of the bacteria isolated from the rhizosphere of wheat showed a stimulative effect: 62% of them stimulated germination and the development of the foliage, while 25% stimulated root formation.

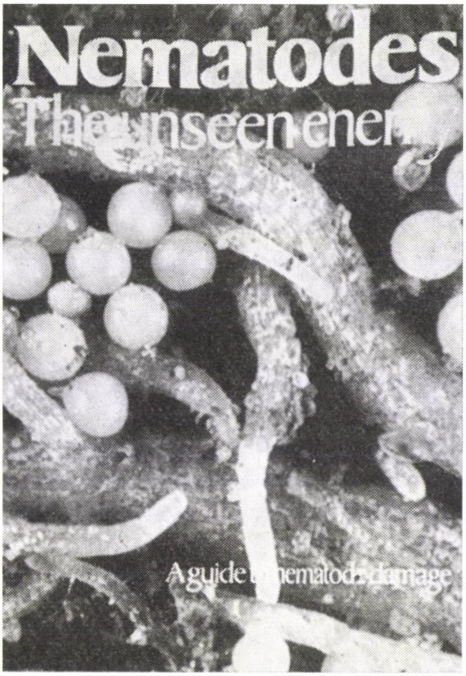
Chapter III deals with the question of interactions between bacteria living in the root nodules (Rhizobia) and papilionaceous plants. From one of the publications the reader may become well acquainted with the procedure by which *Rhizobium* preparations are produced in Hungary. The question arises of whether *Rhizobium* cultures will be able to keep abreast of the ever increasing application of chemicals, or will be eliminated from the soil by a process of selection. Great interest may be aroused by the results of investigations concerning the production of vitamin B_{12} by *Rhizobium leguminosarum*, and by the electro- and coelectrophoresis methods of identifying *Rhizobium* species. The B_{12} production of *Rhizobium leguminosarum* is in close correlation with the N_2-binding ability of the strain, and both properties are influenced by the activity, origin (soil type) and age of the culture. Studies on the efficiency of *Rhizobium* inoculation in the soya varieties introduced within the framework of the Hungarian soya programme are primarily important from a practical point of view.

The fifth chapter of the book discusses soil microorganisms as components in the ecosystem of the soil, while Chapter VI deals with the role played by microorganisms in the processes taking place in the soil. The publications in these two chapters mostly present the results of investigations on the ecology of soil microorganisms. Some of the publications contain recent results in connection with the influence of soil microorganisms on soil formation and soil fertility. The demands made by soil microorganisms on their environment are discussed in the publications from many different points of view. According to the investigations the ratios of the different groups of microorganisms varies extremely with the soil type, so the latter can be characterized by "distinctive microorganism groups". Some microorganisms (e.g. *Arthrobacter*) are resistant to unfavourable ecological factors but are sensitive to human interference, and their role in the life of the soil is therefore unbalanced. The report on the isolation of bacteria which oxidize crude petroleum, propane-butane gas, pentane and hexane is of theoretical and practical importance, as regards both the applied method and the result. The method is likely to arouse wide interest, because it allows the hydrocarbon accumulation to be determined unambiguously. Great practical importance is attached to investigations aimed at settling the soil biology problems related with the cultivation of the slag heaps left by coal mines. According to the experimental results presented in the book the microbiological processes are rapid in two of the three main components of slag heaps (Pannonian sand and decomposed andesite tuff) and slow in the third one (clay). When a fertile soil layer is spread over the slag heaps an intensive decomposition of organic matter (cellulose) begins, which can be enhanced by fertilizer application.

The contents of the book give evidence of the fruitful work carried out by the VIIth Scientific Session on Soil Biology, in the tradition of similar international conferences held previously. No reference has been made here to any of the authors of the 52 publications presented in the book, primarily because each one of them is new of its kind as far as the scientific results are concerned, so the book serves as a rich source for those working in the field of soil biology and, to a certain extent, in the conservation of the biosphere. Thanks are due to the institutions which organized the Scientific Session (Research Institute for Soil Science and Agrochemistry of the Hungarian Academy of Sciences, University of Agricultural Sciences, Keszthely, Committee on Environmental Protection of the Hungarian Association of Agricultural Sciences) for their wise choice of subjects and lectures, to the authors for their research work and lectures, and to the publishing house which, with the co-operation of the editor, has contributed to the propagation of results of theoretical and practical importance.

B. HELMECZI

NIGEL G. M. HAGUE: *Nematodes.* The unseen enemy. A guide to nematode damage. Du Pont de Nemours international S. A. Geneva, 1—20.



The Hungarian literature on plant protection does not abound in publications which deal with the damage caused by parasitic nematodes on agricultural areas and with the possibilities of control.

The 20-page, easily intelligible paper written by Nigel G. M. Hague, the well-known English nematologist, encompasses the most important agronematological problems of world agriculture. The large number of coloured photographs, which illustrate the text and make the abstract problems clearer, give a special value to the work.

To show the extent of the damage caused by nematodes and how expensive control is the author mentions in the introduction that in the United States, for example, chemical control over an area of 1.7 million acres costs 60 million dollars, i.e. the cost of control per unit area is 35 dollars/acre.

Losses caused by phytonematodes generally amount to 6—10%, though in certain fruit-trees and ornamentals the damage may be much greater.

The importance of agronematology as a branch of science will definitely increase in the future, as the ever greater tasks facing world food production can only be accomplished on well-cultivated, fertile soils; but intensive farming provides more favourable life conditions for the nematodes.

The rest of the paper is devoted to a discussion of the biology, damage and control of etiologically differentiated groups of nematodes.

Of the endoparasitic root-gall nematodes *Meloidogyne incognita*, *M. javanica* and *M. arenaria* are described. Among the feed plants of these pests, which have a wide range of host plants including more than 700 crops, most vegetables, fruits and other useful plants can be found. Severe infestations involve serious losses of yield. Attack by these nematodes results in the formation of galls on the root, and the growth of aboveground parts of the plant is checked.

These pests occur primarily in regions with warmer climates, since their life cycle is decisively influenced by the temperature.

In discussing the cyst-forming nematodes the author considers that the damage caused by the potato nematode *(Globodera rostochiensis, Globodera pallida)* is the most important of all. These can be found on every potato-growing area. In the temperate zone they cause damage at sea level, while in the tropics they are characteristic of the highlands. Because of their persistence and fast rate of reproduction serious difficulties are encountered in destroying them. The loss of yield is considerable: every 20 eggs/g soil means a 1 ton loss in yield. Among the cyst nematodes the beet nematode *Heterodera schachtii*, and *Heterodera avenae*, which attacks wheat, barley, rye and oats, are also mentioned. The migrating endoparasites are also an important group of phytonematodes.

Radophulus similis, which is mentioned first, and which is particularly virulent in banana plantations in the tropics, is known as the "digging nematode", since the plants attacked collapse because of root decay. It has two biotypes, a banana strain causing damage only to bananas, and a citrus strain which is at present confined to Florida.

The members of the *Pratylenchus* genus are wide-spread in the temperate zone and the tropics, where the damage they cause is connected with diseases of the soil.

Pratylenchus penetrans, *P. vulnus* and *P. brachyurus* cause the so-called "replantation disease" in fruit-trees.

The *Hirschmanniella* species occur in all rice growing regions of the world and cause damage to the roots of the rice plant.

Scutellonema bradys destroys the roots of yams, and causes considerable losses during storage. *Helicotylenchus multicintus* is a major pest in banana plantations, but also attacks pineapples and citruses.

In the semi-endoparasitic group of nematodes the females are non-migrating. *Tylenchus semipenetrans*, which causes slow destruction in citrus species, is the most important of these. The female is an obligate root pest and following the damage it causes the plant slowly dies. The symptoms are most clearly expressed at the top of the tree.

Rotylenchus reniformis attacks banana, pineapple, sugar-cane, tea, okra and coffee in tropical and subtropical regions.

A separate group of nematodes includes the stem and leaf nematodes which cause damage mostly to the aboveground parts of the plants. *Ditylenchus dipsaci*, one of the most dangerous pests of the temperate zone, is found in this group. The most important of its 450 host plants are flower bulbs, onion, garlic, oats, clover and alfalfa.

Ditylenchus angustus, a rice stalk nematode, causes the "ufra" disease in East India, Burma and other rice growing regions.

The wheat nematode *Anguina tritici* was originally known wherever wheat was grown. Today the major places of its occurrence are India, Romania and Yugoslavia. In consequence of its damage black galls containing thousands of larvae are formed from the wheat grains.

The "white tip" disease in rice is caused by *Aphelenchoides besseyi*, a nematode widespread in the rice growing countries of the world. Its damage extends approximately to a latitude of 40° north.

Apart from the immediate quantitative loss, one group of nematodes causes mainly qualitative damage by spreading the virus diseases of plants. These so-called "virus-vector nematodes" carry the infective virus material in the oesophagus and transmit it from one plant root to the other. The *Xiphinema index* is a migrating ectoparasite which mainly spreads vine viruses. The *Trichodorus* species are the virus vectors of tobacco.

In the last section of the paper the author describes the possibilities of control, emphasizing that a biological knowledge of the different nematode species plays an important role in choosing the right method of control.

One of the control methods is agrotechnical in nature and is based on crop rotation.

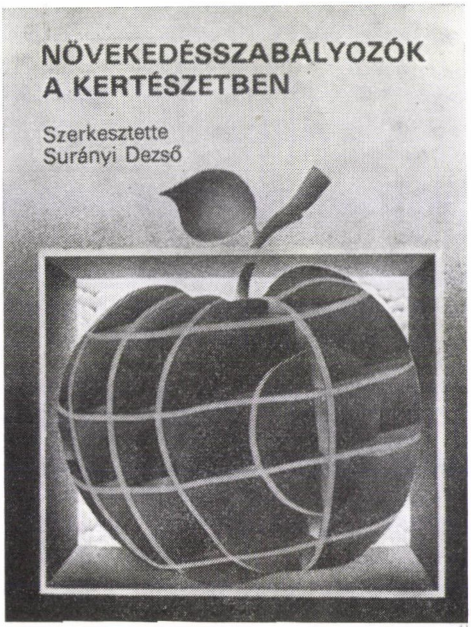
In the case of certain species the temporary absence of the host plant is the only safe way of reducing the population (e.g. *Globodera rostochiensis* in potato).

Hot water treatment is also a reliable standard method in some cases. This is suitable for destroying *Ditylenchus dipsaci* in flower bulbs. Recently plant breeding for resistance is also an efficient method of nematode control.

Chemical control, a method applied all over the world, is only worth using where the crop is highly valuable, as the procedure is very expensive. Apart from soil fumigants (DD, EDB, DBCP), systemic soil disinfecting granulates (e.g. oxamyl) are assuming increasing importance; they are absorbed by the plants and provide protection for some time, depending on the duration of their action. These granulates also have a contact effect in the soil by attacking the choline esterase system of the nematodes.

Cs. Budai

Growth substances in horticulture (Editor: D. Surányi). Mezőgazdasági Kiadó, Budapest, 1978, 323.



The book is a collection of papers by eleven authors on the efficiency of phytohormones and hormone-like synthetic compounds with high biological activity in horticulture (in growing fruit, vegetables, vines and ornamentals). More than a thousand papers are published each year on theoretical and practical questions concerning the role and influence of hormones and regulators, examined alone and in interactions. It is this wide, challenging, but at the same time extremely rapidly developing and theoretically well-grounded subject that the authors have undertaken to summarize and evaluate, basing their work on many years, in cases several decades of experimentation. They have summed up the horticultural application of their results with great competence and a deep sense of vocation, in many cases basing their conclusions on research reports covering several years. The value of the book is increased by descriptions of highly important technologies which are suitable for introduction or are already used in practice. The economic efficiency of horticultural production is discussed in relation to the growth and development of cultivated plants, flower induction, fruit formation and the improvement of qualitative features.

The volume is divided into the following chapters:

Phytohormones, growth substances, and their physiological effects (T. Bubán—D. Surányi). The introductory chapter deals with the role of endogenous and synthetic phytohormones such as auxins, ethylene, gibberellins, morphactines, endogenous and synthetic cytokinins, and compounds with plant growth retardant effects in plant physiology; with the biosynthesis and transport of endogenous hormones; with the influence of these hormones on the transport of metabolites; and with their action on cell differentiation, tissue development, morphological character and the efficiency of plant organization. The hormone interaction is primarily discussed in relation to the plant growth retardants, particularly those which have been used for some years in horticulture.

Possibilities of applying growth substances in fruit growing (T. Bubán—M. Dávid—L. Sebők Lovász—D. Surányi—L. Zatykó). The subjects discussed in this chapter are clone production, seedling development, growth regulation of rootstocks, regulation of branching in grafts, chemical pruning, control of the beginning of bearing in young fruit-trees, control of flower formation, the possibility of influencing fruit setting, ripening and dropping by regulators, and ways of increasing the tolerance and storability of fruits. Auxin-like compounds can be most efficiently used for enhancing the growth and development of cuttings, seedlings and young fruit-trees, and gibberellic acid, gibberellin derivatives and morphactins for the stimulation of flower formation. Young grafts can best be induced to start bearing by treatments with plant growth retardants. The authors give detailed accounts of the results of experiments with regulators which act on the processes of flower formation, fruit setting and ripening; in some cases the technologies are described in the form of a preliminary proposal. The use of regulators is described not only for species of fruit (apple, pear, peach, apricot, plum), but in a number of cases suggestions are also made concerning different varieties, on the basis of data evaluated over several years. Special attention is given in this chapter to the subject of chemical fruit thinning (in peach) and technologies suitable for large-scale practical application are described. The possibility of reducing frost damage by chemical treatments and the prospects of applying chemical pruning represent new tendencies in plant physiology and fruit growing, in theory and practice alike.

Growth substances in vegetable growing (A. Andrásfalvy—D. Surányi). In this chapter the authors discuss the development of the vegetative and generative organs of vegetables, the possibility of controlling apical dominance and of stimulating the development of seedlings by increasing the growth of the roots, etc. By applying the theoretical results in practice and rationalizing the regulator treatments they open up new vistas for increasing the efficiency of expensive vegetable growing operations, with special regard to increased production. The theoretical results and practical achievements attained in the subject are presented in tables, using many vegetables as examples. The results of influencing flower, fruit and seed development by regulator treatments are presented through the summarization of wide-ranging experiments, but many treatments have already been successfully applied in practice, as is emphatically pointed out in the chapter, with suggestions concerning variety, development stage and rate of application. From the point of view of practical production it is particularly important to emphasize the results achieved through the chemical treatment of monoecious plants, in the course of which the proportion of female flowers has been characteristically increased; on the basis of data from pilot experiments, it is already possible to elaborate techniques for regulator application. The authors point out the importance of parthenocarpy and present cases in which it has been induced by regulators, which is a new way of vegetable forcing.

Importance of growth substances in vine growing (J. Eifert—Mrs J. Eifert—N. Jákó—I. Sz. Murányi). The chapter presents results in the field of stimulating the root development of vine cuttings and grafts, callus formation and graft union, chiefly by using synthetic auxins and tryptophane derivatives. These results have been confirmed in practice and are already applied in farm technologies. At the basis research level the authors indicate that attention should be paid to seasonal periodicity when using regulators, and not only the rate of application but also the sensitivity of the variety must be taken into consideration if the technology is to be workable. A detailed survey of varietal sensitivity has made it possible to export the technology elaborated. The study of flowering, seed setting, ripening and frost tolerance, in part by means of regulator treatments, is regarded as an important new field not only from a theoretical point of view, but also because it sets new practical aims for vine growing. Within this complex subject the application of the plant growth retardant type of substances has been given priority. Many regulators, particularly compounds with ethylene precursor effects, have been used in mechanical harvesting; this work is now past the pilot stage and regulators suitable for application in practice are expected to appear in the near future.

A new method of ornamental growing: the use of chemicals (L. Komiszár—L. Sebők

Lovász). Regulators are being increasingly applied in the vegetative and generative propagation of ornamental plants both under greenhouse and field conditions. In most cases, and from the point of view of practical use, the plant growth retardant type of compounds which induce dwarfism have been used most extensively so far. On the other hand, to stimulate forcing and ensure uniform development for propagation stocks gibberellic acid and gibberellins are mostly used. The chapter describes in detail the use of regulators in the storage technology for cut flowers.

There is a subject index at the end of the book, but unfortunately there is no author index and no list of references. On the basis of the ever widening research and the results achieved in practice by treatments with growth substances, it can be seen that although natural and synthetic hormone-like compounds are not miracle cures, they do sometimes work wonders. By presenting examples and counter-examples the authors try to inform their readers in such a way that they will draw the right practical conclusions.

B. I. Pozsár

AUCTORES

BALLA L.
MTA Mezőgazdasági Kutatóintézete,
2462 Martonvásár,
Hungary

BELEA A.
MTA, SzBK Genetikai Intézet,
6701 Szeged,
Odesszai krt. 62.
Hungary

BODA I.
Mezőgazdasági Főiskola,
7401 Kaposvár,
Dénesmajor,
Hungary

BORSOS O.
ELTE Botanikus Kert,
1083 Budapest.
Illés u. 25.
Hungary

BŐJTÖS Z.
GATE Kutatóintézete,
3356 Kompolt,
Hungary

BUDAI CS.
Csongrád megyei Növényvédelmi és Agrokémiai Állomás,
6801 Hódmezővásárhely,
Rárósi út 102.
Hungary

CZIMBER GY.
KATE Növénytani és Növényélettani Tanszék,
9201 Mosonmagyaróvár,
Lucsony u. 15—17.
Hungary

DARAB K.
MTA Talajtani és Agrokémiai Kutatóintézete,
1022 Budapest,
Herman O. u. 15.
Hungary

DOHY J.
Mezőgazdasági Főiskola,
7401 Kaposvár,
Dénesmajor,
Hungary

ERDŐS L.
ELTE Meteorológiai Tanszék,
1088 Budapest,
Múzeum krt. 6—8.
Hungary

FARAG M. A.
Cukortermelési Kutatóintézet
Répatermesztési Kutatóállomása,
9463 Sopronhorpács,
Hungary

FEJÉR O.
MTA, SzBK Genetikai Intézete,
6701 Szeged,
Odesszai krt. 62.
Hungary

HEGEDÜS L.
Semmelweis Orvostörténeti Múzeum,
Levéltár és Könyvtár,
1013 Budapest,
Apród u. 1.
Hungary

HELMECZI B.
DATE Talajtani és Mikrobiológiai Tanszék,
4001 Debrecen,
Böszörményi út 138.
Hungary

HORVÁTH J.
KATE Növényvédelmi Intézet,
8361 Keszthely,
Deák Ferenc u. 16.
Hungary

KOVÁCH Á.
Mezőgazdasági Főiskola,
7401 Kaposvár,
Dénesmajor,
Hungary

KOZMA P.
KE Szőlőtermesztési Tanszék,
1114 Budapest,
Villányi út 35—43.
Hungary

KUGANATHAN A.
Department of Agronomy,
Tamil Nadu Agricultural University,
Coimbatore-641003,
India

LAZÁNYI J.
DATE Kutatóintézete,
5300 Karcag,
Hungary

MAGASSY L.
Cukortermelési Kutatóintézet
Répatermesztési Kutatóállomása,
9463 Sopronhorpács,
Hungary

MANNINGER M.
MTA Mezőgazdasági Kutatóintézete,
2462 Martonvásár
Hungary

NAGY J.
DATE Matematika-Fizika Tanszék,
4001 Debrecen,
Böszörményi út 138.
Hungary

PALANIAPPAN SP.
Department of Agronomy,
Tamil Nadu Agricultural University,
Coimbatore-641003,
India

PÁL GY.
MTA Mezőgazdasági Kutatóintézete,
2462 Martonvásár,
Hungary

PÁLFI G.
JATE Növényélettani Tanszék,
6701 Szeged,
Egyetem u. 2.
Hungary

PÁLFI ZS.
JATE Növényélettani Tanszék,
6701 Szeged,
Egyetem u. 2.
Hungary

PÁSZTOR K.
DATE Növénytermesztési Tanszék,
4001 Debrecen,
Böszörményi út 138.
Hungary

PINTÉR L.
Gabonatermesztési Kutatóintézet,
6701 Szeged,
Alsókikötősor 9.
Hungary

POLLHAMER ZS.
MTA Mezőgazdasági Kutatóintézete,
2462 Martonvásár,
Hungary

POLYÁK D.
KE Szőlőtermesztési Tanszék,
1114 Budapest,
Villányi út 35—43.
Hungary

POZSÁR B. I.
1149 Budapest,
Egressy út 46/a. I. e. 1.
Hungary

PRÉCSÉNYI I.
MTA Botanikai Kutatóintézete,
2163 Vácrátót,
Alkotmány u. 2—4.
Hungary

RABIE H.
DATE Növénytermesztési Tanszék,
4001 Debrecen,
Böszörményi út 138.
Hungary

RAJKI E.
MTA Mezőgazdasági Kutatóintézete,
2462 Martonvásár,
Hungary

RAJKI S.
MTA Mezőgazdasági Kutatóintézete,
2462 Martonvásár,
Hnngary

RAMMAH A. M.
Forage Crops Research Section,
Field Crops Research Institute,
Agricultural Research Centre,
Orman, Giza,
Egypt

SURÁNYI D.
GYDKI Kutatóállomása,
2701 Cegléd,
Szolnoki út 52.
Hungary

SZABOLCS I.
MTA Talajtani és Agrokémiai Kutató-
intézete,
1022 Budapest,
Herman O. u. 15.
Hungary

Szabó M. K.
KE Szőlőtermesztési Tanszék,
1114 Budapest,
Villányi út 35—43.
Hungary

Szilágyi Gy.
MTA Mezőgazdasági Kutatóintézete,
2462 Martonvásár,
Hungary

Szmodits L.
Semmelweis Orvostörténeti Múzeum,
Levéltár és Könyvtár,
1013 Budapest,
Apród u. 1.
Hungary

Szunics L.
MTA Mezőgazdasági Kutatóintézete,
2462 Martonvásár,
Hungary

Udvardy J.
MTA, SzBK Növényélettani Intézet,
6701 Szeged,
Odesszai krt. 62.
Hungary

Varga M.
JATE Növényélettani Tanszék,
6701 Szeged,
Egyetem u. 2.
Hungary

Vöröss L. Zs.
7940 Szentlőrinc,
Bányász u. 6.
Hungary

INDEX

LECTIONES

RECENSIONES

AUCTORES

Workshop on Food and Nutrition

Proceedings of a Workshop on Agricultural Potentiality Directed by Nutritional Needs. June 5-9, 1978, Martonvásár. Ed. by S. Rajki

A scientific workshop on food production and human nutrition, initiated by the United Nations University and organized jointly by the Hungarian Academy of Sciences and the Royal Swedish Academy of Sciences, was held at Martonvásár at the Agricultural Research Institute of the Hungarian Academy of Sciences on June 5–9, 1978 with the participation of invited specialists from the five Nordic countries, the eight socialist countries of Central and Eastern Europe and five special agencies of the United Nations. The participants and invited speakers were some of the most outstanding representatives of their professions in the world.

The proceedings are particularly interesting in that they faithfully reflect:

1. the fact that, due to the diverse cultural and historical backgrounds and the unequal economic development of the peoples of Northern Europe and of Central and Eastern Europe, the participating specialists had quite different attitudes to questions of vital concern to humanity;

2. the interchange of ideas between agriculturalists and nutritionists and the conflict between their views.

The volume includes not only the papers but also a full account of the discussion.

In English. 237 pages. 2 coloured photos. 30 figures. 55 tables. 17 × 25 cm. Cloth
ISBN 963 05 1991 7

AKADÉMIAI KIADÓ, Budapest
Publishing House of the Hungarian Academy of Sciences

Printed in Hungary

A kiadásért felel az Akadémiai Kiadó igazgatója Műszaki szerkesztő: Botyánszky Pál
A kézirat nyomdába érkezett: 1979. XI. 7. — Terjedelem: 21,5 (A/5) ív, 91 ábra

80.7685 Akadémiai Nyomda, Budapest — Felelős vezető: Bernát György

Die Acta Agronomica veröffentlichen agrarwissenschaftliche Abhandlungen, besonders aus dem Bereich der landwirtschaftlichen Grundforschung, in englischer Sprache.

Die Acta Agronomica erscheinen jährlich in einem Band (4 Hefte).

Die zur Veröffentlichung bestimmten Manuskripte sind an folgende Adresse zu senden:

Acta Agronomica
H-2462 Martonvásár, Postafiók 19.

Bestellbar bei »Kultura« Außenhandelsunternehmen (H-1389 Budapest 62, P.O.B. Bankkonto Nr. 218-10-990) oder seinen Auslandsvertretungen.

Les Acta Agronomica publient des communications, en langue anglaise, dans le sujet de la science agricole, surtout du domaine des recherches fondamentales agronomiques.

Les Acta Agronomica sont publiés sous forme de fascicules qui seront réunis en un volume par an.

On est prié d'envoyer les manuscrits destinés à la rédaction à l'adresse suivante:

Acta Agronomica
H-2462 Martonvásár, Postafiók 19.

On peut s'abonner à l'Entreprise du Commerce Extérieur « Kultura » (H-1389 Budapest 62, P.O.B. 149, Compte-courant No. 218-10-990) ou chez représentants à l'étranger.

Acta Agronomica публикает статьи по аграрной тематике, главным образом теоретические работы в области сельскохозяйственных основных наук.

«Acta Agronomica» выходит выпусками, составляющими один том в год.

Предназначенные для публикации рукописи следует направлять по адресу:

Acta Agronomica
H-2462 Martonvásár, Postafiók 19.

Заказы принимает предприятие по внешней торговле «Kultura» (H-1389 Budapest 62, P.O.B. 149, Текущий счет № 218-10-990) или его заграничные представительства и уполномоченные.

Reviews of the Hungarian Academy of Sciences are obtainable at the following addresses:

AUSTRALIA
C.B.D. LIBRARY AND SUBSCRIPTION SERVICE, Box 4886, G.P.O., *Sydney N.S.W. 2001*
COSMOS BOOKSHOP, 145 Ackland Street, *St. Kilda (Melbourne), Victoria 3182*

AUSTRIA
GLOBUS, Höchstädtplatz 3, *1200 Wien XX*

BELGIUM
OFFICE INTERNATIONAL DE LIBRAIRIE, 30 Avenue Marnix, *1050 Bruxelles*
LIBRAIRIE DU MONDE ENTIER, 162 Rue du Midi, *1000 Bruxelles*

BULGARIA
HEMUS, Bulvar Ruski 6, *Sofia*

CANADA
PANNONIA BOOKS, P.O. Box 1017, Postal Station "B", *Toronto, Ontario M5T 2T8*

CHINA
CNPICOR, Periodical Department, P.O Box 50, *Peking*

CZECHOSLOVAKIA
MAD'ARSKÁ KULTURA, Národni třida 22, *115 66 Praha*
PNS DOVOZ TISKU, Vinohradská 46, *Praha 2*
PNS DOVOZ TLAČE, *Bratislava 2*

DENMARK
EJNAR MUNKSGAARD, Norregade 6, *1165 Copenhagen*

FINLAND
AKATEEMINEN KIRJAKAUPPA, P.O. Box 128, *SF-00101 Helsinki 10*

FRANCE
EUROPERIODIQUES S. A., 31 Avenue de Versailles, *78170 La Celle St.-Cloud*
LIBRAIRIE LAVOISIER, 11 rue Lavoisier, *75008 Paris*
OFFICE INTERNATIONAL DE DOCUMENTATION ET LIBRAIRIE, 48 rue Gay-Lussac, *75240 Paris Cedex 05*

GERMAN DEMOCRATIC REPUBLIC
HAUS DER UNGARISCHEN KULTUR, Karl-Liebknecht-Strasse 9, *DDR-102 Berlin*
DAUTSCHE POST ZEITUNGSVERTRIEBSAMT, Strasse der Pariser Kommüne 3—4, *DDR-104 Berlin*

GERMAN FEDERAL REPUBLIC
KUNST UND WISSEN ERICH BIEBER, Postfach 46, *7000 Stuttgart 1*

GREAT BRITAIN
BLACKWELL'S PERIODICALS DIVISION, Hythe Bridge Street, *Oxford OX1 2ET*
BUMPUS, HALDANE AND MAXWELL LTD., Cowper Works, *Olney, Bucks MK46 4BN*
COLLET'S HOLDINGS LTD., Denington Estate. *Wellingborough, Northants NN8 2QT*
WM. DAWSON AND SONS LTD., Cannon House, *Folkestone, Kent CT19 5EE*
H. K. LEWIS AND CO., 136 Gower Street, *London WC1E 6BS*

GREECE
KOSTARAKIS BROTHERS, International Booksellers, 2 Hippokratous Street, *Athens-143*

HOLLAND
MEULENHOFF-BRUNA B.V., Beulingstraat 2, *Amsterdam*
MARTINUS NIJHOFF B.V., Lange Voorhout 9—11, *Den Haag*
SWETS SUBSCRIPTION SERVICE, 347b Heereweg, *Lisse*

INDIA
ALLIED PUBLISHING PRIVATE LTD., 13/14 Asaf Ali Road, *New Delhi 110001*
150 B-6 Mount Road, *Madras 600002*
INTERNATIONAL BOOK HOUSE PVT. LTD., Madame Cama Road, *Bombay 400039*
THE STATE TRADING CORPORATION OF INDIA LTD., Books Import Division, Chandralok, 36 Janpath, *New Delhi 110001*

ITALY
EUGENIO CARLUCCI, P.O. Box 252, *70100 Bari*
INTERSCIENTIA, Via Mazzé 28, *10149 Torino*
LIBRERIA COMMISSIONARIA SANSONI, Via Lamarmora 45, *50121 Firenze*
SANTO VANASIA, Via M. Macchi 58, *20124 Milano*
D. E. A., Via Lima 28, *00198 Roma*

JAPAN
KINOKUNIYA BOOK-STORE CO. LTD., 17-7 Shinjuku-ku 3 chome, Shinjuku-ku, *Tokyo 160-91*
MARUZEN COMPANY LTD., Book Department, P.O. Box 5050 Tokyo International, *Tokyo 100-31*
NAUKA LTD. IMPORT DEPARTMENT, 2-30-19 Minami Ikebukuro, Toshima-ku, *Tokyo 171*

KOREA
CHULPANMUL, *Phenjan*

NORWAY
TANUM-CAMMERMEYER, Karl Johansgatan 41—43, *1000 Oslo*

POLAND
WĘGIERSKI INSTYTUT KULTURY, Marszalkowska 80, *Warszawa*
CKP I W ul. Towarowa 28 *00-958 Warszawa*

ROUMANIA
D. E. P., *Bucureşti*
ROMLIBRI, Str. Biserica Amzei 7, *Bucureşti*

SOVIET UNION
SOJUZPETCHATJ — IMPORT, *Moscow*
and the post offices in each town
MEZHDUNARODNAYA KNIGA, *Moscow G-200*

SPAIN
DIAZ DE SANTOS, Lagasca 95, *Madrid 6*

SWEDEN
ALMQVIST AND WIKSELL, Gamla Brogatan 26, *S-101 20 Stockholm*
GUMPERTS UNIVERSITETSBOKHANDEL AB, Box 346, *401 25 Göteborg 1*

SWITZERLAND
KARGER LIBRI AG, Petersgraben 31, *4011 Basel*

USA
EBSCO SUBSCRIPTION SERVICES, P.O. Box 1943, *Birmingham, Alabama 35201*
F. W. FAXON COMPANY, INC., 15 Southwest Park, *Westwood, Mass. 02090*
THE MOORE-COTTRELL SUBSCRIPTION AGENCIES, *North Cohocton, N. Y. 14868*
READ-MORE PUBLICATIONS, INC., 140 Cedar Street, *New York, N. Y. 10006*
STECHERT-MACMILLAN, INC., 7250 Westfield Avenue, *Pennsauken N. J. 08110*

VIETNAM
XUNHASABA, 32, Hai Ba Trung, *Hanoi*

YUGOSLAVIA
JUGOSLAVENSKA KNJIGA, Terazije 27, *Beograd*
FORUM, Vojvode Mišića 1, *21000 Novi Sad*

18. VII. 1980

Index: 26.001
HU ISSN 0001—513X